# Northern Goshawk (*Accipiter gentilis atricapillus*): A Technical Conservation Assessment

**Prepared for the USDA Forest Service, Rocky Mountain Region, Species Conservation Project**

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## Author's Biography

Patricia Kennedy (Pat) received her B.A. in Biology from Colorado College in 1975, her M. S. in Zoology from the University of Idaho in 1980 and her Ph.D. in Biology/Ecology from Utah State University in 1991. After completing her graduate work Pat was hired as an Assistant Professor in the Department of Fishery and Wildlife Biology at Colorado State University in Ft. Collins, Colorado. She was promoted to Associate Professor in 1997. In January 2002, Pat moved to northeastern Oregon where she is currently an Associate Professor in the Department of Fisheries and Wildlife at Oregon State University. She is stationed at the Eastern Oregon Agricultural Research Center in Union, Oregon. Pat's current research interests are focused on understanding the effects of livestock grazing and timber management practices on avian populations and communities. She has authored and co-authored over 35 publications, book reviews and reports. Nineteen of these publications are on the goshawk and she received a USDA Forest Service Meritorious Award for her role as adviser to the Goshawk Scientific Committee which developed national guidelines for managing the goshawk.

## Cover Photo Credit

2S6986
Northern Goshawk (*Accipiter gentilis*). Western, US.


## List of Errata

# EXECUTIVE SUMMARY

## *Status*

The northern goshawk (*Accipiter gentilis atricapillus*; hereafter referred to as goshawk) has been proposed for listing several times under the Endangered Species Act and its status has been (and still is) the object of considerable litigation. It is currently not listed as a threatened species but is considered a sensitive species or a species of concern by most governmental agencies and non-governmental organizations within Region 2. Currently, there is no demographic evidence in North America (including Region 2) that the goshawk is declining. This lack of evidence can be interpreted in two ways: 1) the goshawk is not declining; or 2) it is declining but I don't have sufficient information to detect the declines. In Region 2, there is clearly insufficient data to determine population status. However, within Region 2, Partners in Flight suggest the goshawk may be declining in the Central Rocky Mountain Physiographic Region, which occurs in the extreme northwest section of the region. The basis for this conclusion is unknown but is likely based on the threat of habitat alteration to the goshawk's preferred breeding season habitat.

## *Primary Threats*

The primary threat to goshawk populations is alteration of its preferred habitat from timber management practices. Biologists and land managers have raised concerns over destruction and modification of goshawk nesting, post-fledging, foraging, and wintering habitat. Although the goshawk uses a wide range of forest communities during the breeding season, it prefers mature and old-growth forest for nesting and hunting. Its winter habitat preferences in North America are poorly understood but the limited data from North America and Europe suggest the bird can use the same habitats year-round as well as non-forested habitats at lower elevations. Although there is some evidence goshawks are resilient to forest fragmentation and can re-establish when cleared areas are reforested, the thresholds for population persistence have not been identified.

The issues cited by researchers, agency personnel, and others as potential threats to habitat caused by various silvicultural treatments include forest fragmentation, creation of even-aged and monotypic stands, potential increase in area of younger age classes, and loss of tree species diversity. The degree to which habitat alteration is impacting goshawks in Region 2 is unknown. This is primarily due to a paucity of regional data on the spatial and temporal trends of habitat change due to current management practices. However, a recent landscape study conducted in the San Juan Mountains of Colorado suggests significant changes in landscape structure and fragmentation of mature forest have occurred in this area between 1950-1993. During this period, roughly half of the mature conifer forest has been converted to young stands and there has been a 3-fold increase in road density. If this area is representative of Region 2 forest lands, these results suggest landscape structure has changed dramatically on forest lands in Region 2 since the 1950s. The degree to which these landscape changes impact regional goshawk persistence is unknown. However, if the trend in the San Juan Mountains is representative of regional trends, goshawk habitat is probably declining in Region 2.

## *Primary Conservation Elements, Management Implications and Considerations*

The most effective approach for managing breeding populations of goshawks is to manage goshawks at a variety of spatial scales. This requires a landscape management plan of goshawk preferred habitat. To the extent that goshawk management is a priority, most goshawk guidelines recommend Region 2 develop a landscape management plan rather then continuing to establish small buffer zones around nest trees. One approach that could be used in Region 2 is the approach developed in the *Management Recommendations for the Northern Goshawk in the Southwestern United States* (Reynolds et al. 1992). This approach is focused on developing desired forest conditions within goshawk home ranges and for developing an implementation plan to obtain those desired conditions. Reynolds et al. (1992) cannot be applied as a “cookbook” to Region 2 because the habitat types and forest conditions differ. However, the approach could be modified for regional conditions by a team of biologists and silviculturists with regional expertise.

For effective goshawk management to occur in the region, I have identified several information needs which include both information on goshawks and regional databases that clearly summarize vegetative trends in Region 2.

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# Introduction

This assessment addresses the biology of the northern goshawk (*Accipiter gentilis atricapillus*; hereafter referred to as goshawk) throughout its range in Region 2 (**Figure 1**). The broad nature of the assessment leads to some constraints on the specificity of information for certain locales. Furthermore, completing the assessment promptly required limiting the geographic scope of particular aspects of the assessment and further analysis of existing (but unanalyzed) field data. These limitations are described later in this introduction. This introduction outlines the scope of the assessment and describes the process used in it.

### *Goal of Assessment*

Species assessments produced as part of the Species Conservation Project are designed to provide forest managers, research biologists, and the public a thorough discussion of the biology, ecology, and conservation status of certain species based on scientific knowledge accumulated prior to initiating the assessment. The purpose of this document is to provide biological background upon which conservation strategies for the goshawk and its ecosystems can be based. Thus, the assessment goals limit the scope of work to critical summaries of scientific knowledge, discussion of broad implications of that knowledge, and outlines of information needs. The assessment does not seek to develop specific management recommendations but provides the ecological background upon which management must be based. Although the assessment does not make management recommendations, it does attempt to describe the consequences of changes in the environment that could result from management. Furthermore, it cites management recommendations proposed elsewhere and, when management recommendations have been implemented by others, the assessment examines the success of the implementation (Hayward et al. 2000).

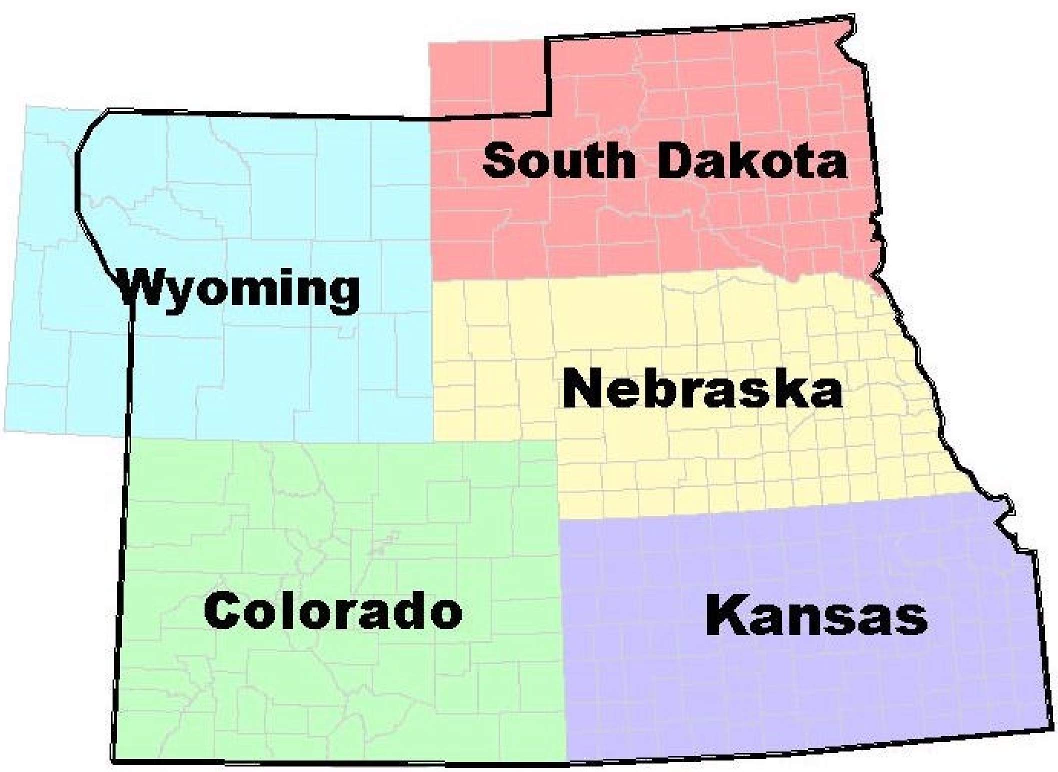


**Figure 1.** Map of U.S. Forest Service, Rocky Mountain Region (Region 2).

### *Scope of Assessment*

The goshawk assessment examines the biology, ecology, and management of this species with specific reference to the geographic and ecological characteristics of the central Rocky Mountain Region (Region 2 - Colorado, Kansas, Nebraska, South Dakota and Wyoming). The organization of this document is based on the Species Conservation Assessment Outline provided by Region 2. Although a majority of the literature on the species may originate from field investigations outside the region, this document places that literature in the context of the ecological and social context of the central Rockies. Similarly, this assessment is concerned with movements, behavior, population dynamics, and other characteristics of goshawks in the context of the current environment rather than under historical conditions 200, 2000, or 2 million years ago. The evolutionary environment of the species was considered in conducting the synthesis, but placed in a current context.

In producing the assessment, I reviewed refereed literature and non-refereed publications, e.g., government reports, theses and dissertations. I recently co-authored two management documents on the goshawk for the Western Great Lakes Region (Kennedy and Andersen 1999 and Roberson et al. 2002) that required extensive literature reviews. I have relied broadly on material in these two documents in preparing this report. In addition, several reviews of goshawk studies have been written in recent years (Braun et al. 1996, Kennedy 1997, Squires and Reynolds 1997), providing valuable comparisons and a comprehensive scope of available information, and are cited frequently in this assessment.

Not all publications on goshawks are referenced in the assessment, nor were all published material considered equally reliable. Literature that was not included does not mean these studies were inferior scientifically. Rather, the results were not directly relevant to the conservation assessment. The assessment emphasizes refereed literature because this is the accepted standard in science. Non-refereed publications or reports were regarded with greater skepticism. I chose to use some non-refereed literature in the assessments, particularly when information was unavailable in the published literature. Data accumulated by resource management agencies, much of which are not contained in publications or written reports, were important in estimating the goshawk's regional distribution and patterns of habitat use. These data required special attention because of the diversity of persons and methods used to collect the data. Special attention should be given to non-refereed publications or data as these sources of information have not been subjected to a formal screening process (Millsap et al. 1998; Hayward et al. 2000).

Because there are many gaps in our knowledge about goshawks, a large portion of this assessment is devoted to recommendations for future research necessary to provide a scientifically-based conservation strategy, the next step in the regional management process. I review gaps in existing knowledge necessary to manage the goshawk. I then prioritize future research with a focus on knowledge most critical to management planning.

Producing species assessments rapidly to make information available for Forest Plan Revision leads to tight timelines. The goal to produce assessments rapidly limited the analysis of existing, unpublished data or attempts to conduct meta-analyses to synthesize information from published literature. Summarized data from regional, unpublished goshawk studies would have been included in this document if such information were available. The regional office requested such data summaries during the spring of 2001 but none were provided. Thus, regional information in this document is based on regional data summarized in the refereed literature and non-refereed reports.

The timeline established for completing the assessment and regional data available within that timeline did not allow me to gather some critical information. In particular, I was unable to examine current federal land management plans to discern the direction of forest management and its potential impacts on goshawks. I did not have access to sufficient information to assess trends in the abundance of mature and old-growth forests. Finally, although I recognize the utility of demographic analyses in assessing species status, I was unable to build and examine demographic models for the goshawk based on the existing demographic data.

### *Role of the Scientific Process*

Science represents a rigorous, systematic approach by which humans gain understanding of nature. Competing ideas regarding how the world works are measured against observations. Research and reliability of knowledge gained from research depend on appropriate application of the scientific method. Unfortunately not all research in wildlife ecology and management is reliable knowledge. Unreliable knowledge can result from inappropriate application of the scientific method in the design and implementation of these studies (Romesburg 1981; Nudds and Morrison 1991) and/or confusing subjective, political values with objective, technical knowledge (Nudds and Morrison 1991; Kennedy 1997; White and Kiff 1998).

Romesburg (1981) argued that much wildlife science was compromised with respect to providing the reliable knowledge required to make management decisions. He stated that "good science" should be that best able to provide reliable knowledge, and that is based on the hypothetico-deductive (H-D) method. This method employs 3 steps: observation/induction (the use of repeated observations to discover laws of association), hypothesis formulation, and tests of these hypotheses, preferably with experimentation. It also includes a methodology for dealing with uncertainty. Romesburg (1981) pointed out that some accepted knowledge about wildlife is untested hypotheses about observations because many studies go through the first 2 steps but not the third. Induction can provide us with reliable knowledge about associations such as the association of goshawks with forests having certain structural characteristics. However, this method does not provide the mechanism for understanding the processes that underlie this association nor does it provide reliable knowledge about cause and effect. Thus, I can describe the structure of forests used by goshawks, but I cannot ascertain which characteristics are "important" or why, without application of the H-D method. We can describe patterns through induction but need the H-D method to understand why these patterns occur and which components of those patterns are "important." In terms of management, understanding why a pattern has occurred and what caused it are important for predicting effects when observed patterns are changed via management or other processes (U. S. Fish and Wildlife Service 1995).

As Nudds and Morrison (1991) point out, there is resistance to using the H-D method in wildlife biology. The resistance includes claims that: 1) nothing is yet known about a system, so hypotheses are not apparent, 2) funding agencies do not support tests of hypotheses, and 3) the H-D method is impossible if experiments are impractical. Nudds and Morrison address these challenges and I summarize their response below.

*Challenge 1 — Hypotheses are not apparent because the system is unknown.* If few data exist, then more are required, and there will always be a need for this type of information. This challenge just reflects the need for more research. I would also ask the following question: if there are few data, e.g., ecological information on many endangered species, how can I justify developing a management plan and spending public dollars to implement a plan based on no information?

*Challenge 2 — Funding is not available for hypothesis tests.* Attitudes of administrators in many agencies are changing. Examples include the U.S. Forest Service, which has embraced the concept of adaptive management, which is management by experimentation, evaluation and new management experiments based on evaluation results (Walters and Holling 1990). Administrators are realizing they should be able to justify why they spend money on tests of hypotheses – it explicitly evaluates the cost-effectiveness of their management actions.

*Challenge 3 — the H-D method is impossible if experiments are impractical.* This argument assumes that doing H-D means doing only manipulative, controlled, replicated experiments. However, this argument rests on a very narrow definition of experimentation. As Nudds and Morrison (1991) and Murphy and Noon (1991) point out, this challenge does not recognize that what is most important about the H-D approach is the attempt to falsify hypotheses and erect better ones. H-D research is not characterized by whether or not it is experimental, because hypotheses can be evaluated with non-experimental data (Ratti and Garton 1994). Data collected in non-experimental or descriptive studies are more limited in terms of their reliability (e.g., can't infer cause and effect from non-experimental data), but they can be used to test hypotheses and are certainly better then ignoring hypothesis testing completely. However, well-designed descriptive studies that include unbiased sampling techniques, adequate sample sizes and appropriate statistical tests can be used to evaluate management hypotheses.

My approach to interpreting data (Sections III and IV) and making recommendations for data collection (Section IV) are based on the philosophies of Romesburg and Nudd and Morrison. Although I do not use this rigorous approach to evaluate every single study cited in this document, my interpretations of the available data and my recommendations for future studies reflect this philosophy. The Endangered Species Act (ESA) calls for the use of the best scientific data in conserving threatened or endangered species and the ecosystems upon which they depend (Smallwood et al. 1999). This approach should apply to management of sensitive species such as the goshawk. Management of sensitive or listed species should be science based as described above and not based on subjective judgments as is commonly done (Kennedy 1997, Smallwood et al. 1999).

### *Treatment of Uncertainty*

To be scientific, data must contain an assessment of their uncertainty. If data are used to develop models [e.g., Gap Analysis Program (GAP), population viability analyses (PVAs)] or explore hypotheses, uncertainties should be incorporated into the conclusions reached. Numerous techniques exist for such uncertainty analyses, e.g., assigning uncertainty distributions to model parameters using Monte Carlo simulations or use of expert opinion to estimate data gaps, but they are rarely used in development of conservation plans (Smallwood et al 1999). Thus, scientific reliability of the data used to develop these plans is difficult to evaluate. In this assessment I either present authors' uncertainty estimates, e.g., 95% confidence intervals, or discuss it qualitatively when it is relevant to the interpretation of the data.

### *Limitations of Data Used in This Assessment*

Most of the information collected on goshawk biology and ecology in the U.S. is from outside of Region 2 and it is unclear to what degree this information can be applied to management of goshawk populations in Region 2. However, this information from outside the region was used to describe general goshawk biology and ecology. Most studies from Region 2 were conducted in limited portions of one state and none have been conducted on a regional scale with spatial replication. None of these study locations were randomly selected, which limits inference to region-wide trends [see Yoccoz et al. (2001) for a discussion of the problems associated with the lack of spatial replication in monitoring studies].

The published information from Region 2 is primarily from Wyoming and there is some unpublished information from South Dakota and Wyoming. Because many of the studies included in this conservation assessment are unpublished, written descriptions of study designs, methods, and analytical techniques are not always available for critical analysis, have not been through critical peer review as part of the scientific publication process, and should therefore be interpreted cautiously. Scientific data are meaningless without proper use and interpretation by scientists. The data need scientific evaluation of their limitations and uncertainties, and their interpretation requires knowledge of the most current scientific theory and methodologies. The process of science is greatly enhanced by the peer review process. When data are not subject to peer review they are what is referred to as "gray literature." Gray literature has value where expedience in publication is useful or where the author is targeting a specific audience (Millsap et al. 1998, Smallwood et al. 1999). However, it has less scientific value than similar data subjected to the peer-review process (Millsap et al. 1998).

In this assessment, the strength of evidence for particular ideas will be noted and alternative explanations described when appropriate. While well-executed experiments represent a strong approach to developing knowledge, alternative approaches such as modeling, critical assessment of observations, and inference will be accepted as sound approaches to understanding. Although there maybe debate about the "best" technique of investigation (experiments versus field investigation, mathematical modeling versus statistical description) such debates often reflect the different types of questions people want to ask, or the types of scientific explanation with which they will be satisfied (Ford 2000). However, a key component of good science is the use of appropriate inference given a particular methodology. For example, if an investigator monitors reproductive success of a population of goshawks in Colorado and the nest sites were not selected randomly, the investigator's inference is limited to the sample of nests used in the study. This does not invalidate the data, but I do not know if the sample of nests is a representative sample of Region 2.

### *Treatment of This Document as a Web Publication*

To facilitate use of species assessments in the Species Conservation Project, assessments are being published on the Region 2 Web site. Placing the documents on the Web makes them available to agency biologists and the public more rapidly than publication as a book or report. More important, revision of the assessments will be facilitated. Revision will be accomplished based on guidelines established by Region 2 and available on this Web site.

### *Peer Review of This Document*

Assessments developed for the Species Conservation Process have been peer reviewed prior to release on the Web. The peer review was accomplished through Sustainable Ecosystems Institute (SEI), an independent scientific organization. SEI secured the services of two recognized scientists, with a background in ecology, management, and goshawk biology who provided critical input on revision of the draft document.

## Management Status and Natural History

### *Legal, Regulatory, Conservation and Management History*

I begin this section with a summary of goshawk litigation history. It is appropriate in this section because the controversy over goshawk protection has manifested itself in two separate, but related, legal arenas: the development of forest management guidelines under the National Forest Management Act (NFMA) and listing of the goshawk under the ESA.

#### History of goshawk litigation – National Forest Management Act

Based on the findings of Crocker-Bedford (1990) and unpublished research conducted on the Kaibab National Forest in Arizona, environmental organizations sought more extensive protection of goshawk habitat. They thought that current logging practices threatened goshawk viability and thus, violated the NFMA (Peck 2000). This resulted in:

> 02/1990 - Formal request to Region 3 regional forester to suspend all harvesting in goshawk territories until long-term survival was assured.
>
> 08/1990 - Regional forester organized a Goshawk Scientific Committee (GSC) and Goshawk Task Force (GTF) to review goshawk management needs in Region 3.
>
> 06/1992 - GSC produced the Management Guidelines for the Northern Goshawk in the Southwestern Region (Reynolds et al. 1992). This management plan is described in more detail in the section on History of goshawk conservation/management.
>
> 1992-1995 - The Reynolds et al. (1992) document generated intense controversy. The focus of the controversy was whether or not the goshawk was a forest generalist. The Reynolds et al. document claimed that goshawk populations were regulated by prey availability and that the data suggest the goshawk is a prey generalist and thus, hunts

in heterogeneous landscapes. The opposing state agencies and environmental groups claimed (without any supporting data) that the goshawk was an old-growth obligate. Other concerns are detailed in Peck (2000).

1996 - The regional forester for Region 3 issued a Record of Decision (ROD) to amend all regional forest plans to include the Reynolds et al. (1992) guidelines as well as recommendations from the Mexican spotted owl (*S. o. lucida*). This ROD is to be in effect for 5-10 year until the forest plans are revised (scheduled to be completed by 2003) (Cartwright 1996). This is the only region to implement Reynolds et al. (1992) on a regional basis.

## History of goshawk litigation – Endangered Species Act

Most of the information below is from four sources: 1) Judge Helen J. Frye's opinion at http://pacific.fws.gov/news/pdf/Frye_SJ_opinion.pdf; 2) USFWS (U.S. Fish & Wildlife Service) - status review at http://pacific.fws.gov/news/pdf/gh_sr.pdf; 3) USFWS "not warranted" finding at http://pacific.fws.gov/news/pdf/gh_find.pdf; 4) E. Paul, Executive Director, Ornithological Council (personal communication); and 5) Peck (2000).

### *Accipiter gentilis atricapillus*

09/26/1991 - Petition filed to list the goshawk (*Accipiter gentilis atricapillus*) as endangered west of 100th meridian.

01/1992 - The goshawk (all subspecies) was listed as a candidate species (Category 2) for possible future listing under the ESA throughout its range in the United States. Category 2 species were those species for which there was inadequate data to justify a listing proposal under ESA at that time. At issue, among other things, was whether a listing was justified, given the relatively healthy status of the species in eastern North America. Of concern was the goshawk's place in ecosystems as an "indicator species." An "indicator species" is one in which changes in its population levels may reveal changes in its overall habitat. According to many experts, decline of the northern goshawk was due, at least in part, to timber harvests, but other causes were also widely cited. Some feared that listing the species would further reduce timber harvests in western states.

06/25/1992 - USFWS denies western petition on taxonomic grounds (57 FR 474-76).

05/1995 - Suit filed to overturn denial.

02/1996 - Court rules that listing refusal was arbitrary and capricious, orders USFWS to issue another decision (926 F. Supp. 920 (D. Ariz. 1996)).

06/06/1996 - USFWS issues second decision, again denying listing on taxonomic grounds (61 FR 28, 834-35).

09/1996 - Suit filed to overturn denial.

06/1997 - Court overturns second denial as arbitrary and capricious, also finding the USFWS national policy on listing populations to be illegal, orders a new decision (980 F. Supp. 1080 (D. Ariz. 1997). The USFWS Final Policy on Distinct Population Segments (DPS) allowed for only one subspecies per distinct population segment. The USFWS claimed, in the 1997 phase of the litigation, that there were three subspecies of Northern Goshawk west of the 100th meridian: 1) *Accipiter gentilis atricapillus, 2) A. g. laingi,* and *3) A. g. apache.* The Court found that this aspect of the DPS policy was arbitrary and capricious because the ESA specifically states that in the definition of "species", a "species" may include *any* subspecies and *any* distinct population segments of *any species.* If Congress had intended that a DPS contain only one subspecies, it would have allowed only the listing of "DPSs" of subspecies. The Court then remanded the case back to the USFWS, which led to the positive 90-day finding in 1997 (Ellen Paul, Executive Director, Ornithological Council, personal communication).

09/19/1997 - Candidate status dropped. Prior to 1997, the USFWS maintained a "Category 2" list that included species whose status was unknown but of concern due to declines in population trend or habitat. These were also referred to as "Candidate Species". Thus, the goshawk was no longer considered a candidate for listing due to the lack of information supporting a proposed rule (M. Nelson, Chief, Branch of Candidate Conservation, USFWS).

09/29/1997 - USFWS issues a positive 90-day finding on western petition (62 FR 50, 892). It was then required to conduct a full status review by 06/1998, either proposing to list the goshawk as endangered or not.

06/29/1998 - USFWS issues negative 12-month finding, refusing to propose listing as endangered (63 FR 35, 183). See summary of these findings in the paragraphs below.

02/25/1999 - Suit filed to overturn denial.

06/28/2001 - The USFWS's decision not to list the goshawk as a threatened or endangered species was upheld by a federal judge, who found that the Service's decision was not arbitrary and capricious. *Excerpts from press release*: In a ruling issued June 28, 2001, United States District Court Judge Frye said "there is ample evidence in the administrative record" to support the Service's decision that the listing of the goshawk in the contiguous United States, west of the 100th meridian, is not warranted because available information does not indicate that this population is in danger of extinction or likely to become so in the foreseeable future.

"This court has found that the U.S. Fish and Wildlife Service collected the available information, considered all relevant factors and made a reasoned decision based upon credible, substantial evidence in the record," Judge Frye wrote in her opinion. Anne Badgley, Regional Director of the USFWS's Pacific Region, said the judge's opinion affirms the Service's careful approach to reviewing citizen petitions for listing species. "Even when I don't have as much information as I would like I must make a decision on the basis of what I do have," Regional Director Badgley said. "This ruling supports our finding that the available information does not show a decline in goshawk populations or a continuing trend of goshawk habitat curtailment in the western United States."

The USFWS based its decision not to list the goshawk on a review of existing data and the findings of a status review team of nine biologists (including two USFS biologists). The team sent its draft status review information to 99 state, tribal and federal agency biologists and to 13 goshawk researchers to review the analytical methods and approach used by the USFWS. The status review team found that it was not possible to determine whether the goshawk population numbers in the review area were stable, increasing, or decreasing, but they concluded that the distribution of breeding goshawks in the West did not appear to have changed from the historical range.

Based on available information, the USFWS also found that the goshawk is a "forest habitat generalist" and is not dependent solely on old-growth forests. Judge Frye found "significant studies in the administrative record that support this finding." Among those she cited was a 1996 report by The Wildlife Society (TWS), an organization of professional wildlife scientists, who concluded "no evidence was presented to indicate that northern goshawk populations are declining, threatened or endangered in the Southwest or anywhere within its range, and I find no evidence of a long-term decline in goshawk breeding populations."

Judge Frye also ruled that it was not improper for the USFWS to include two U.S. Forest Service employees on the status review team because national forest land accounts for much of the goshawk's habitat in the western United States.

The case was brought against the USFWS on Feb. 25, 1999, by the Center for Biological Diversity and 18 other organizations, who claimed that the USFWS's decision to not list the goshawk was arbitrary and capricious. The plaintiffs had petitioned the Service in 1991 to list the goshawk for protection under the federal ESA.

2001 - Suit filed to challenge logging on 3.24 million ha of forest in the southwest. The plaintiffs have asked for an injunction on logging within goshawk habitat on 11 Arizona and New Mexico National Forests until the USFS prepares a new goshawk conservation plan.

06/15/01 - A federal judge ruled that the suit challenging logging in goshawk habitat in the southwest is "ripe" for review. The status of this suit is still pending.

*Accipiter gentilis laingi*

05/1994 - Petition filed to list the Queen Charlotte goshawk (*Accipiter gentilis laingi*) as endangered. The petition was based largely upon the present and impending impacts to the Queen Charlotte goshawk caused by timber harvest in the Tongass National Forest.

08/26/1994 - USFWS published a positive 90-day finding (59 FR 44124) stating that substantial information was presented in the petition indicating that the requested action may be warranted.

05/19/1995 - after a 12-month status review, USFWS decided that listing was not warranted. Notice of this finding was published on June 29, 1995 (60 FR 33784). In the 12-month finding, the USFWS acknowledged that continued large-scale removal of old-growth forest in the Tongass National Forest would result in significant adverse effects on the Queen Charlotte goshawk in southeast Alaska; however, at that time the USFS was revising land use strategies to ensure goshawk habitat conservation. The USFWS believed that the proposed actions to protect goshawks would preclude the need for listing.

11/17/1995 - Suit filed against the Department of the Interior and the USFWS for their refusal to list the Queen Charlotte goshawk or designate critical habitat.

09/25/1996 - The U.S. District Court remanded the 12-month finding to the Secretary of Interior, instructing him to reconsider the determination "on the basis of the current forest plan, and status of the goshawk and its habitat, as they stand today."

12/15/1996 - USFWS reopens comment period (61 FR 64497) to gather all new information for review. It was extended until April 4, 1997 through three subsequent notices (61 FR 69065, 62 FR 6930, and 62 FR 14662). The USFWS has reevaluated the petition and the literature cited in the petition, reviewed the Tongass Land Management Plan and other available literature and information, and consulted with biologists and researchers knowledgeable of northern goshawks in general, and the Queen Charlotte goshawk in particular. The 1979 Tongass National Forest Land Management Plan, as amended, formed the basis for evaluating the status of the goshawk on the Tongass National Forest. On May 23, 1997, the USFS issued a revised Tongass Land Management Plan. Consequently, the review of the 1979 Tongass Land Management Plan no longer represented the "current'' plan as specified by the court ruling. The USFWS was, therefore, granted a 90-day extension to reevaluate the status of the goshawk under the provisions of the 1997 Tongass Land Management Plan.

02/14/1997 - Comment period re-extended.

03/05/1997 - Comment period re-extended.

06/12/1997 - USFWS re-extends comment period.

04/15/1998 - Suit filed to overturn the USFWS's refusal to list the Queen Charlotte goshawk as an endangered species.

02/25/1999 – Suit filed to list all subspecies of northern goshawks in all western states. Note that the suit filed in 1998 is still pending at this time. This 02/25/1999 suit only applies to the contiguous 48 states west of the 100th meridian, so this suit is not relevant to the Queen Charlotte goshawk.

07/20/1999 - Judge Stanley Sporkin threw out the USFWS's decision not to list the Queen Charlotte goshawk as endangered in southeast Alaska, insular British Columbia, the Olympic Peninsula, and possibly coastal Washington and Oregon. The judge agreed that the agency did not use the best science in making its decision. The USFWS is ordered to "make a more reliable determination of the Queen Charlotte goshawk population."

Sometime in late 1999 or early 2000 - The Department of the Interior appealed Judge Sporkin's decision to the Circuit Court.

06/16/2000 - The Circuit Court stated that the District Court exceeded its authority in ordering the government to conduct a population count. So the Circuit Court reversed the District Court and remanded the case to the District Court for consideration of the basic issue - did the USFWS rely on the best available evidence? As of 10/15/2001 (E. Paul, personal communication) no action has been taken in the District Court.

In summary, there have been 8 and 11 years of litigation over the federal status of *Accipiter gentilis laingi* and *A. g. atricapillus*, respectively. No changes in listing status have resulted from this litigation.

### International

The International Union for the Conservation of Nature (IUCN) is the organization that evaluates the status of all species globally and produces red lists for each taxonomic group, e.g., birds, fish, flowering plants. They have no regulatory authority so these lists are purely informative and used to develop conservation strategies worldwide. The goshawk is not listed by the IUCN (**Table 1**). The global conservation status rank for the Association for Biodiversity Information is G5, which means the species is secure and is abundant and widespread. The global ranking system is based on Masters (1991) and is used by the Natural Heritage Programs in some states (**Table 1**) and by some Canadian provinces. The goshawk is given a global conservation rank because of its holarctic distribution.

The Queen Charlotte goshawk has been red-listed (is a candidate for Endangered or Threatened status) in British Columbia by the provincial government, and in 2000 was designated as vulnerable by the Committee on the Status of Endangered Wildlife in Canada (Cooper and Chytyk 2000, Cooper and Stevens 2000). British Columbia added this subspecies to its provincial red list with a ranking of S2B (the breeding population is imperiled provincially because of extreme rarity; 1000 - 3000 remaining individuals). The non-breeding population of this subspecies is not listed because it is considered a diffuse, moving population and static non-breeding occurrences cannot be mapped (Provincial Rank SZN) (http://www.env.gov.bc.ca/rib/wis/cdc/red_blue). The goshawk is federally listed as threatened in Mexico (http://www.conabio.gob.mx/proyectos/semarnap16102000.PDF; Spanish translated by R. Orrantia, CSU).

### United States

The conservation status of the goshawk for federal, state and non-governmental organizations is presented in **Table 1**. The goshawk is listed as a Species of Concern in all regions of the USFWS and is on the USFS Sensitive Species list for all regions including Region 2. It is a Bureau of Land Management (BLM) Sensitive Species in 6 State Offices (**Table 1**).

### Region 2

The goshawk is listed as a Sensitive Species by the USFS in Region 2 (**Table 1**). Each region develops its own criteria to evaluate sensitive species but in most regions, a species is considered sensitive if a decline in either population abundance or habitat conditions suggests it is trending towards endangerment (Squires et al. 1998). It is also listed as a BLM Sensitive Species in two of the State Offices within the region (CO and WY).

**Table 1.** Status of the northern goshawk by federal and state agencies and non-governmental organizations.[1]

| Organization | Region / State | Status / Listing | Sources |
|---|---|---|---|
| BLM | 6 State Offices (ID, CO NV, NM, OR/WA and WY) | Sensitive Species | Eric Lawton, BLM, personal communication, December 2002 |
| USFWS | Region 1 | Species of concern (1995)[2] | http://migratorybirds.fws.gov/reports/speccon/tblconts.html |
| | Region 2 | Species of concern (1995)[2] | http://migratorybirds.fws.gov/reports/speccon/tblconts.html |
| | Region 3 | Species of concern (1995)[2] | http://migratorybirds.fws.gov/reports/speccon/tblconts.html |
| | Region 4 | Species of concern (1995)[2] | http://migratorybirds.fws.gov/reports/speccon/tblconts.html |
| | Region 5 | Species of concern (1995)[2] | http://migratorybirds.fws.gov/reports/speccon/tblconts.html |
| | Region 6 | Species of concern (1995)[2] | http://migratorybirds.fws.gov/reports/speccon/tblconts.html |
| | Region 7 | Species of concern (1995)[2] | http://migratorybirds.fws.gov/reports/speccon/tblconts.html |
| USFS | Region 1 | Sensitive species | Greg Hayward, personal communication, September 2001[3] |
| | Region 2 | Sensitive species | Greg Hayward, personal communication, September 2001[3] |
| | Region 3 | Sensitive species | Greg Hayward, personal communication, September 2001[3] |
| | Region 4 | Sensitive species | Greg Hayward, personal communication, September 2001[3] |
| | Region 5 | Sensitive species | Greg Hayward, personal communication, September 2001[3] |
| | Region 6 | Sensitive species | Greg Hayward, personal communication, September 2001[3] |
| | Region 8 | Sensitive species | Greg Hayward, personal communication, September 2001[3] |
| | Region 9 | Sensitive species | Greg Hayward, personal communication, September 2001[3] |
| | Region 10 | Sensitive species | Greg Hayward, personal communication, September 2001[3] |
| Colorado Division of Wildlife | Colorado | Not listed[4] | http://www.dnr.state.co.us/wildlife/T&E/list.asp |
| Kansas Dept. of Wildlife & Parks | Kansas | No information found[5] | http://www.kdwp.state.ks.us/ |
| Nebraska Game & Parks Commission | Nebraska | Not listed[4] | http://ngpc.state.ne.us/wildlife/ngthreat.html |
| South Dakota Game, Fish & Parks | South Dakota | Globally - G5[6]<br>Statewide - S3B[7] S2N[8] | http://www.state.sd.us/gfp/DivisionWildlife/Diversity/RareAnimal.htm#animals |
| Wyoming Game & Fish Dept. | Wyoming | WYGF - NS4[9] | Bob Oakleaf, personal communication, August 2001[10] |
| International Union for the Conservation of Nature | Global | No listing in 2000 red list | http://www.redlist.org/info/categories_criteria.html#categories |
| The Nature Conservancy | Colorado | S3B[7] SZN[11] | http://www.natureserve.org/[12] |
| | Kansas | SZN[11] | http://www.natureserve.org/[12] |
| | Nebraska | S?N[13] | http://www.natureserve.org/[12] |
| | South Dakota | S3B[7] S2N[8] | http://www.natureserve.org/[12] |
| | Wyoming | S2B[14] / S3B[7] S4N[15] | http://www.natureserve.org/[12] |

**Table 1.** Concluded.

| Organization | Region / State | Status / Listing | Sources |
|---|---|---|---|
| Natural Heritage Programs | Colorado | Globally - G56<br>Statewide - S3B7S2N8<br>Tracking status - Watchlisted | http://www.cnhp.colostate.edu/docs/splist.html<br>Colorado Natural Heritage Program. 1999. Conservation Status Handbook: Colorado's Animals, Plants, & Plant Communities of Special Concern pp. 18 & 22. Colorado State University. Fort Collins, Colorado. |
| | Kansas | Not listed[4] | http://www.kbs.ukans.edu/ |
| | Nebraska | Not listed[4] | http://www.abi.org/nhp/us/ne/birds.html |
| | South Dakota | Globally - G5[6]<br>Statewide - S3B[7] S2N[8] | http://www.state.sd.us/gfp/DivisionWildlife/Diversity/RareAnimal.htm#animals |
| | Wyoming | Same as WY Game & Fish Dept. Classification | http://uwadmnweb.uwyo.edu/wyndd/Birds/bird.htm & Bob Oakleaf, personal communication, August 2001[10] |

[1]Status and listing as of July 2001, unless specified otherwise; data are subject to change.

[2]Status of the bird in process of being revised based on Partners In Flight information, and is expected to be published on September 2001. John Trapp, personal communication, August 2001.

[3]Greg Hayward, Regional Wildlife Ecologist for Region 2, USFS, based on information from a national database.

[4]Not listed indicates sensitive or threatened and/or endangered species lists for the organization were found but the northern goshawk was not listed.

[5]No information found indicates sensitive and/or threatened and endangered species lists were not found; hence it is unknown whether or not the northern goshawk is listed by the organization.

[6]G5 - Demonstrably secure, though it may be quite rare in parts of its range, especially at the periphery.

[7]S3B - Either very rare and local throughout its range, or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction throughout its range because of other factors; in the range of 21 to 100 occurrences (breeding season).

[8]S2N - Imperiled because of rarity (6 to 20 occurrences or few remaining individuals or hectares) or because of some factor(s) making it very vulnerable to extinction throughout its range (non-breeding season).

[9]NS4 - Native species that does not have a high enough priority to warrant special management.

[10]Non-Game Biologist, Wyoming Game and Fish Department.

[11]SZN - No definable occurrences for conservation purposes, usually assigned to migrants (non-breeding season).

[12]Full citation for all Nature Conservancy data is: NatureServe: An online encyclopedia of life [web application]. 2001. Version 1.4. Arlington, Virginia, USA: Association for Biodiversity Information. Available: http://www.natureserve.org/.

[13]S?N - Not yet ranked (non-breeding season).

[14]S2B - Imperiled because of rarity (6 to 20 occurrences or few remaining individuals or hectares), or because of some factor(s) making it very vulnerable to extinction throughout its range (breeding season).

[15]S4N - Apparently secure, though it may be quite rare in parts of its range, especially at the periphery. Cause for long term concern.

*State agencies and organizations*

The states of Colorado and Nebraska do not have the goshawk listed on any of the state lists (**Table 1**). Both South Dakota and Wyoming use the species rankings developed by the Natural Heritage Programs to assign a status to the goshawk. These rankings are modifications of those proposed by Masters (1991). Breeding populations in South Dakota are ranked as S3B, which is defined as either very rare and local throughout its range, or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction throughout its range because of other factors (**Table 1**). The non-breeding population is ranked as S2N, which is defined as imperiled because of rarity or because of some factor(s) making it very vulnerable to extinction throughout its range. We found no information on the status of the goshawk in Kansas (**Table 1**).

*Partners in flight*

In the near future, the state and federal agencies will have available for consideration the Partners in Flight (PIF) species prioritization process that was developed to help set national and regional conservation priorities. PIF was created in 1980 in response to concern for declining populations of neotropical, migratory songbirds. In subsequent years, PIF expanded its mandate to include all non-harvested land birds. A major objective of the PIF species prioritization process was to develop a system that could be applied consistently to any group of species, in any geographic area, and in any season. Initial development has focused on breeding avifauna of North America north of Mexico. However, in the future it will expand to include breeding birds south of the Mexico-U.S. border, as well as wintering and transient birds (Carter et al. 2000).

A series of scores is assigned to each species, ranging from 1 (low priority) to 5 (high priority) for several parameters that reflect different degrees of need for conservation attention (**Table 2**). These scores are assigned within physiographic regions (**Figure 2**) which are a modification of the original Breeding Bird Survey (BBS) boundaries established in the 1960's (Greg Butcher, personal communication, Aldrich 1963 , Robbins et al. 1986). I also include the local goshawk scores for each of the physiographic areas (**Table 2**), which were obtained from the Rocky Mountain Bird Observatory PIF database (http://www.rmbo.org/pif/pifdb.html). PIF criteria include the percent of a species' population occurring in each of the physiographic areas and the species residency status. The organization provides scores for the importance of the area to the species for each season, which reflects the abundance of the species in the particular physiographic area relative to the rest of the species' range (Carter et al. 2000). Other variables include past and future threats to the species that are tabulated to produce an overall threat score. Finally, population trends for the breeding season are determined based primarily on BBS data (Carter et al. 2000). However, as Carter et al. (2000) indicate, one of the most common misinterpretations of the PIF data is the reliance on total scores only, without considering the component scores (**Table 2**). Also, given that rangewide abundance trends do not exist for this species (see Section III.I.7) and that raptors cannot be surveyed effectively using the BBS, I am skeptical about these scores since they are based on absent or potentially spurious estimates of abundance.

**Table 2.** Partners In Flight conservation status scores for the northern goshawk in each of the physiographic areas encompassing the states of Colorado, Kansas, Nebraska, South Dakota, and Wyoming which occur in US Forest Service Region 2.

| | | | Breeding | | | | Wintering | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Physiographic area number[1] | Area name | % of goshawk population in physiographic area | Occurrence | Area importance[2] | Threats[3] | Breeding population trend | Occurrence | Area importance[2] | Winter threats to non-breeding[3] | Threats to migratory, non-breeding populations[3] |
| 33 | Osage Plains | No entry[4] | No entry[4] | No entry[4] | No entry[4] | No entry[4] | Y | 1 | 3 | No entry[4] |
| 34 | Central Mixed Grass Prairie | No entry[4] | No entry[4] | No entry[4] | No entry[4] | No entry[4] | Y | 1 | 3 | No entry[4] |
| 36 | Central Short Grass Prairie | No entry[4] | No entry[4] | No entry[4] | No entry[4] | No entry[4] | Y | 2 | 3 | No entry[4] |
| 37 | Northern Mixed Grass Prairie | No entry[4] | No entry[4] | No entry[4] | No entry[4] | No entry[4] | Y | 3 | 3 | No entry[4] |
| 38 | West River | No entry[4] | No entry[4] | No entry[4] | No entry[4] | No entry[4] | Y | 2 | 3 | No entry[4] |
| 39 | Northern Shortgrass Prairie | 0.69 | Y | 2 | 4 | No data[5] | Y | 3 | 3 | 3 |
| 62 | Southern Rocky Mountains | 1.64 | Y | 5 | 2 | No data[5] | Y | 4 | 3 | 3 |
| 64 | Central Rocky Mountains | 9.19 | Y | 5 | 3 | Poss. dec. | Y | 4 | 3 | 3 |
| 86 | Wyoming Basin | 0.09 | Y | 2 | 3 | No data[5] | Y | 4 | 3 | 3 |
| 87 | Colorado Plateau | 0.32 | Y | 2 | 3 | No data[5] | Y | 2 | 3 | 3 |

[1]For distribution of physiographic areas in USFS region 2 (Colorado, Kansas, Nebraska, South Dakota and Wyoming) refer to Figure 2.

[2]Scores for area importance are as follows (adapted from Carter et al. 2000): 1 - Accidental to peripheral; 2 - Occurs regularly but is uncommon; 3 - Present in low relative abundance; 4 - Present in moderate to high relative abundance; 5 - Present in highest relative abundance.

[3]For possible threat interpretation combinations refer to Table 3.

[4]No entry indicates a blank cell in the original PIF data (http://www.rmbo.org/pif/pifdb.html).

[5]No data is the original entry as it appears in the PIF database (http://www.rmbo.org/pif/pifdb.html).

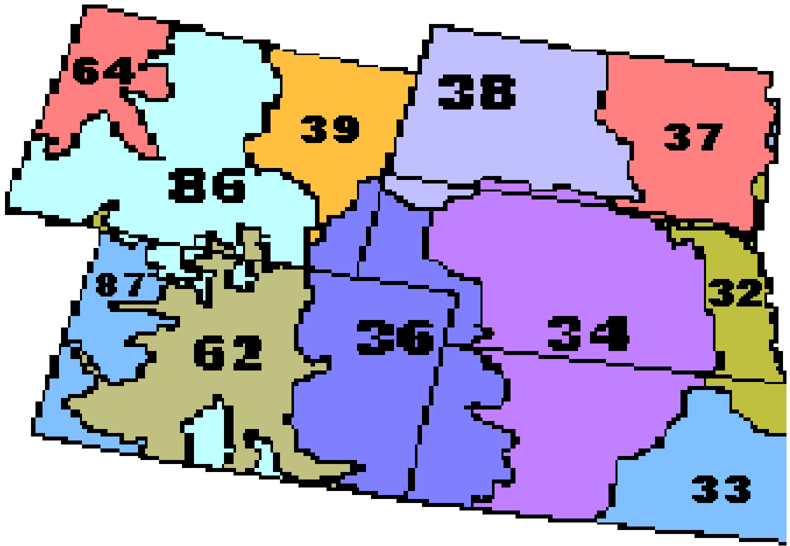


**Figure 2.** Distribution and numbers of physiographic areas for the states of Colorado, Kansas, Nebraska, South Dakota, and Wyoming as defined by Partners In Flight (from http://www.blm.gov/wildlife/pifplans.htm). These areas are described in more detail in Table 2.

The PIF rankings suggest the goshawk is a species of moderate concern within Region 2 because it is experiencing moderate threats during both winter and summer (primarily due to habitat loss), and populations within at least one physiographic area (Central Rocky Mountain Physiographic Region – northwest corner of Region 2) maybe declining. I must stress that these results should be interpreted very cautiously since I am unaware of any trend data for the goshawk within any of these physiographic provinces and I do not know how PIF estimated the percent of past conditions present today. I agree with Beissinger et al. (2000), who suggested the PIF process should include an uncertainty score to assess the confidence in species' ranks. I would predict that the goshawk rank would have a high degree of uncertainty.

## *Existing Regulatory Mechanisms and Management Plans*

### History of goshawk conservation/management

In the 1970s, several threats facing the goshawk and its nesting habitat were recognized in goshawk habitat studies (Bartelt 1977, Hennessy 1978, Reynolds 1989). Designated as an indicator of mature and old-growth forests by the USFS in the 1980s, the goshawk was selected as a management indicator species for land management plans in at least 49 national forests (USFWS 1998a).

In the 1980s, management recommendations were developed for western coniferous forests to protect nest areas, and proposed that an 8.1-ha buffer of uncut habitat be left in timber sale areas around two active and two replacement nest sites per nest area (Reynolds 1983). An evaluation of the 8.1-hectare (ha) buffer guidelines in Arizona suggested these small buffers were not adequate to protect nest areas (Crocker-Bedford and Chaney 1988, Crocker-Bedford 1990). The size of the nest buffers has been traditionally driven by economic pressures rather than goshawk biology and is generally considered too small to provide adequate protection (Bosakowski 1999).

One of the earliest ecosystem or broad scale management plans for goshawks was developed by Forsman (1980; in Bosakowski 1999) for the Fremont National Forest in Oregon. It was based on the idea that forest communities are not static, succession occurs, and potential nest sites need to occur in all seral stages for future use. His plan also integrates the concept of alternative nest sites into goshawk management. He presented plans for an old-growth rotation (250 years) schedule at goshawk nest sites, which included rotation of 6 potential nest groves (10.2-12.1 ha) within a typical goshawk home range (estimated at 2,428-2,832 ha). At time 0, two of the sites should be old-growth (250+ years), two in mature forest (100-140 years), and two in second-growth stands (0-35 years). After 100-140 years the two old-growth sites could be harvested as the mature sites turn into old-growth. Also during the first 140 years, he thought it might be possible to thin the youngest stand several times as long as at least 10 overstory trees and 121 understory trees per ha were present at 120 years. No mention was made of timber management on the remaining areas of the goshawk home range, (e.g., foraging area) (Bosakowski 1999).

For Oregon goshawks, Reynolds (1983) recommended goshawk nest sites (8.1-10.2 ha) not be harvested nor be isolated by silvicultural treatments from the remainder of the home range. He also suggested goshawk pairs be provided two potentially active and two replacement nest sites. He recommended that tree harvests (including thinning) not occur in active nest or replacement sites because it might reduce their desirability as nest sites (Bosakowski 1999). No mention was made of timber management on the remaining areas of the goshawk home range.

Crocker-Bedford (1990) recommended timber harvest be avoided within the entire home range of the goshawk, thereby extending the nest buffer area from 8.1 ha to 1,619 - 2,023 ha. As an alternative that would allow for greater timber production, he suggested dividing the foraging area into three structural classes: a dense canopy with an open understory structure to provide prime goshawk habitat, a maturing forest of marginal goshawk habitat, and areas subject to harvest. Each class would be subjected to even-age management with rotation periods well beyond what is optimum for timber yields. He further suggested each territory be divided into continuous thirds of 1,000-2,000 ha to minimize the number of openings created in the forest canopy and the amount of forest edge effects (Peck 2000).

As mentioned in the previous section, the GSC, as assembled by the USFS, Southwestern Region, completed a document in 1992 entitled *Management Recommendations for the Northern Goshawk in the Southwestern United States* (Reynolds et al. 1992). Reynolds et al. (1992) developed these guidelines for southwestern goshawk habitat [ponderosa pine (*Pinus ponderosa*), mixed conifer and spruce-fir forests]. They assessed information available on goshawk ecology, with particular attention on goshawk prey and the ecology of key prey species in the region, as well as ecology of the forests used by goshawks and local silvicultural practices. The recommendations are designed to provide good breeding season habitat for the goshawk and 14 of its key prey species (Fuller 1996).

In summary, this plan recommends: 1) no timber harvest in three nest areas (12.1 ha each) per home range; 2) provide 3 additional nest areas within each home range for future use by goshawks and these can receive intermediate treatment or prescribed burning; 3) timber harvest rotation in the postfledging family area (PFA, 170 ha) and foraging area (2,185 ha), always maintaining <u>a minimum</u> of 60% in late-successional forests (tree classes 31-46 cm, 46-62 cm and 62+ cm); 4) restricted management season in nest areas and PFA from October through February; 5) openings of 0.4-1.6 ha depending on forest type; and 6) maintenance of reserve trees (1.2-2.4/ha), canopy cover, snag densities (0.8-1.2/ha), downed logs (1.2-2/ha), and woody debris (11.2-13.6 metric tons/ha) in all harvest areas with amount depending upon forest type (Bosakowski 1999).

The specific management recommendations were designed for returning current forest conditions (which have been impacted by grazing, fire suppression and timber management) to a mix of patches of various successional stages and a relatively open forest dominated by mature trees. The applicability of this approach to managing goshawk landscapes may not be limited to southwestern forests. As noted by Fuller (1996), the concept of Reynolds et al. (1992) could be used as a model, for assessments and strategies in other areas and for other species. However, similar to many wildlife management plans, Reynolds et al. (1992) still remains an untested hypothesis. Although these guidelines have been adopted by the USFS in Arizona and New Mexico (USFS 1995, 1996), their effectiveness at enhancing goshawk population persistence in this landscape has not been evaluated. Braun et al. (1996) and Drennan and Beier (in press) have expressed concerns about the single-species focus of these guidelines and question the practice of managing landscapes for goshawks.

Austin (1993) developed goshawk management recommendations based on her radio telemetry studies of goshawks in California. She recommended goshawk management areas be based on the average combined area used by a breeding pair of goshawks (4,765 ha). Within that area she recommended at least 20% retention of mature/old-growth forest, 40% retention of small sawtimber, and no greater than 10% in seedling/sapling/grass-forb stage. These recommendations were more conservative than the Reynolds et al. (1992) recommendations, which considered a smaller management area (983 ha) and allowed up to 40% of the area in young successional stages (Bosakowski 1999).

Graham et al. (1994) extended the ideas in Reynolds et al. (1992) that forest conditions are temporally and spatially dynamic. Instead of managing individual home ranges, they suggested goshawk management should focus on managing large forest tracts as sustainable ecological units. According to Bosakowski (1999), some national forests in the Pacific Northwest are providing similar management to that prescribed by Reynolds et al. (1992) for nest sites and PFAs, but no management is being conducted on the foraging areas.

Recently Finn et al. (2002) developed goshawk habitat management recommendations for the Olympic Peninsula in Washington. They were based on their analysis of goshawk nesting habitat at multiple spatial scales. Their results suggest goshawk use of the landscape on the Olympic Peninsula as nesting habitat will be maximized where at least 54% of the home range is late-seral stage forest. (defined as > 70% coniferous canopy closure with > 10% of canopy from trees > 53 cm dbh and < 75% hardwood/shrub) and no more than 17% is stand initiation (regenerating clearcuts; conifers < 7 years old, < 10% coniferous canopy closure). They also suggest that reducing the amount of landscape contrast and edge density (indices of spatial heterogeneity) within home ranges may increase occupancy as will maintain potential nest areas.

There is general agreement among goshawk biologists that goshawk management requires providing suitable nest stands and a large landscape for foraging. However, the need for managing intermediate scales (e.g., PFA) and very small scales (the nest site) is still open to debate. I will discuss this further in the sections on goshawk habitat requirements and management.

### Habitat management in Region 2

#### *U.S. Forest Service*

Comprehensive management recommendations have not yet been developed for Region 2, due in part to the lack of available information on goshawk demography, habitat use in the region and a lack of standardized monitoring methodology that can be applied region-wide. However, some (but not all) of the districts survey project sites for new nests, monitor territory occupancy and/or reproductive success of known nests sites, and provide protection measures for active goshawk nests. Verner (1996) and Schultz et al. (2000) describe the goshawk management approaches currently in use in Region 2 and I summarize these below.

**Surveys for new nest sites:** Some districts survey project areas for new nest sites. However, no region-wide protocol is used for these surveys. The survey approaches range from "creative, intuitive meandering" (Schultz et al. 2000) to using broadcast surveys based on Kennedy and Stahlecker (1993). Some districts do not allocate funds specifically for goshawk surveys but these units will report incidental observations of goshawk nests to state agencies or Heritage programs.

**Monitoring known nest sites:** Some districts regularly monitor known nest sites for annual nest site occupancy and productivity. A few districts band nestlings and breeding adults. However, due to funding limitations nest monitoring is usually inconsistent or sporadic. Some districts do no monitoring of known nest sites. Most forests in Region 2 do little or no consistent nest monitoring outside of ongoing project areas.

**Data storage:** Region 2 has contracted with state Natural Heritage programs (NHPs) to record and archive nest location data collected within the region. These records are available to Forest Service biologists. Many District and Forest Supervisor offices maintain local databases of known goshawk nest sites. Schultz et al. (2000) estimate that up to 25% of all known goshawk nest sites in Region 2 stay in these local databases and go unreported to the NHPs. Thus, there is no one centralized database that can be used to analyze regional data on nesting goshawks.

**Data analysis:** Although data collection is occurring in parts of Region 2 on goshawk reproduction, these data are being filed with no apparent plan for data analysis on a regular basis. This suggests that data analysis and data summaries are not included in the plans for nest surveys and nest monitoring.

**Protection measures:** There is a wide variety of mitigation and/or protective measures used within the region to benefit and protect goshawk nest stands and foraging habitat. As Schultz et al. (2000) indicate, this variety could be interpreted as an example of a lack of a cohesive conservation strategy for goshawks within Region 2. They also note that it probably reflects the variability of management actions, public use demands, occupied habitats and general behavioral plasticity of goshawks across the region.

The most common protective measure used in Region 2 is to create no-use or limited use buffer zones around known nest sites. These buffer zones can range from 182-400 m from known nest sites. Seasonal restrictions (restricted activity during the breeding season) may be applied to activities that occur near the buffer zone boundaries.

Some districts use a variety of approaches to mitigate loss of goshawk nesting habitat within timber harvest areas. For example, one district retains 2-3 groups of 4-5 older trees (dbh > 30.5 cm) as potential nesting areas within timber harvest areas. Another district thins these areas to maximize tree growth and enhance hiding or screening cover (Schultz et al. 2000).

**Habitat management for goshawks:** As noted in the section History of goshawk conservation/management, Reynolds et al. (1992) recognized that goshawk nesting habitat is not just the currently known 8.1-12.1 ha nest stand. This small area is the location of courtship, incubation and raising nestlings. However, the nest area expands considerably once the young fledge and this area used by the family is called the post-fledging area or PFA (supported by radio-telemetry data on post-fledging movements by Kenward et al. (1993a) and Kennedy et al. (1994). The PFA also includes alternative nest sites that could be used in the future.

Some of the revised forest plans in Region 2 have incorporated PFA management into their standards and guides. Examples of PFA management include (from Schultz et al. 2000):

> Limit management activities in at least three known nest stands (approximately 12.1 ha each) or three replacement stands within each historically active territory.
>
> Management activities should not reduce the structural and compositional integrity of active and alternative nest stands.
>
> From March 1-September 30, avoid timber harvest schedules that cause simultaneous, widespread disturbance across goshawk fledgling habitat (the PFA).
>
> Management treatments in the PFA associated with active and alternative nests should be designed to enhance prey species habitat, and structural and compositional diversity.

None of the current forest plans in Region 2 include management of the foraging area, a key component of the goshawk home range.

**State management of goshawks:** No specific monitoring or habitat management approaches are used by any of the state agencies within Region 2. However, all states within the region allow a limited harvest of goshawks for falconry. Some states only allow a resident harvest, e.g., Colorado, South Dakota, and some states allow a non-resident harvest, e.g., Wyoming. There are currently no upper limits on the number that could be harvested because the demand is so low. For example, in Colorado 0-11 birds are harvested annually, in Wyoming 5-6 birds are taken annually (B. Oakleaf, Wyoming Department of Fish and Game, personal communication), and in South Dakota 0-2 are harvested annually (D. Backlund, South Dakota Game, Fish and Parks, personal communication). Currently there are 30 raptors kept by falconers in Nebraska and 2 of these are goshawks, which were not harvested in Nebraska (J. Dinan, Nongame Avian Biologist, Nebraska Game and Parks Commission). No comparable falconry data are available for Kansas. Based on the federal falconry regulations, only nestlings and juvenile birds (passage birds) outside of the breeding season can be harvested in Colorado, South Dakota and Wyoming. Only passage birds can be harvested in Nebraska and no breeding birds can be harvested.

### Are current laws, regulations and enforcement sufficient?

#### *National Forest Management Act*

Goshawk management on USFS lands is covered under The National Forest Management Act ("NFMA;" 16 U.S.C. 1601 et seq.; amending the Forest and Rangeland Renewable Resources Planning Act of 1974). The requirements of the NFMA are intended to eliminate the need to list any vertebrates occurring to a large extent on National Forest lands. According to USFWS (1998b), some believe full implementation of NMFA provisions would require funding and personnel levels far in excess of current resources. For goshawks, assurance of "viable populations", as defined in the NMFA, would require knowledge of habitat requirements currently not well understood, and an inventory and monitoring program beyond the capacity of current budgets. Considering the goshawk is but one of thousands of vertebrate species on National Forest lands, meeting NMFA mandates presents a considerable challenge (USFWS 1998b).

In their status review of the goshawk the USFWS (1998b) noted that some National Forests provide meaningful protection for goshawks. In 2001, all of the Forest Service Regions listed goshawks as "sensitive species", which are recognized by the Forest Service as needing special management to prevent being placed on Federal or State lists (**Table 1**). Such designation requires biological evaluations to consider potential impacts to the species of any proposed management actions. Forest Service Region 3 has amended the forest plans for its 11 National Forests to incorporate the recommendations of Reynolds et al. (1992) (USFS 1995, 1996). In 1998 the USFWS thought that these management recommendations, if properly implemented, might provide a level of habitat protection necessary to maintain goshawks on the landscape over time in the Southwest. However, they noted that results from implementation monitoring and effectiveness monitoring programs will be needed to actually assess how consistently and effectively the guidelines are being implemented and if the goshawks are responding to the guidelines as suggested by Reynolds et al. (1992).

Other regions (e.g., Regions 4 and 10) and some National Forests (e.g., the Chippewa National Forest in Region 9) have developed, or are in the process of developing goshawk environmental assessments or management effects analysis (R. T. Reynolds, USDA Forest Service, personal communication, Roberson et al. 2002). A detailed description of goshawk management approaches in Region 9 is in Roberson et al. (2002). It is too early in the implementation stage of these programs to determine whether or not these approaches will effectively manage goshawk populations.

Region 2 and the associated state agencies may not be managing goshawks effectively based on the inconsistent way in which management is applied from district to district and the lack of state management plans. Hopefully, this conservation assessment will facilitate development of region-wide approaches to managing goshawks in Region 2. Currently there is no information available to determine whether or not Sensitive Species are effectively managed under NMFA, particularly after the USFWS dropped the Category 2 listings. This decision may have significantly impacted sensitive-species management because it may have decreased the political impetus to manage sensitive species before they become endangered (Squires et al. 1998).

*Falconry*

There are no data to indicate falconry harvest is impacting national, regional or local goshawk populations. The annual harvest numbers are low throughout the region and do not warrant special management. However, Jerry Craig with the Colorado Division of Wildlife mentioned concerns about localized overharvest that might be occurring in parts of Colorado and perhaps elsewhere.

## *Biology and Ecology*

### Systematics and general species description.

*Systematics*

Common Name: Northern Goshawk
Scientific Name: *Accipiter gentilis* (Linnaeus 1758)
<u>Taxonomy</u>
Order: Falconiformes
Suborder: Accipitres
Superfamily: Accipitroidea
Family: Accipitrididae
Subfamily: Accipitrinae [American Ornithologists' Union (AOU) 1998]

Approximately 8 to 12 subspecies of goshawks exist worldwide depending on the taxonomic source (Brown and Amadon 1968, del Hoyo et al. 1994, Squires and Reynolds 1997). Originally described by Linnaeus in 1758, the northern goshawk is holarctic in distribution, with two groups recognized worldwide: the Palearctic *gentilis* group [American Ornithologists' Union (AOU) 1983], consisting of several subspecies found in Eurasia, and the Nearctic *atricapillus* group consisting of *Accipiter gentilis atricapillus* and *A. g. laingi*. The *atricapillus* group occurs over much of Alaska, Canada, and the mountains of the western and eastern U.S. Although some authorities recognize 3 subspecies in North America (Johnsgard 1990), the AOU (1957, 1983) recognizes only 2: *A. g. atricapillus* and *A. g. laingi*. *Accipiter gentilis apache* is not recognized by the AOU as a legitimate subspecies and the USFWS considers this issue to be unresolved (1998b). *Accipiter gentilis apache* is, however, recognized by some scientists (Snyder and Snyder 1991, Hubbard 1992, Whaley and White 1994).

*Accipiter gentilis atricapillus*, the subspecies found in Region 2 and therefore the subject of this conservation assessment, inhabits most of the North American range of the species. The Queen Charlotte goshawk, *A. g. laingi*, breeds on Queen Charlotte and Vancouver Islands (Taverner 1940), possibly extending north to Baranof Island in southeast Alaska or Prince William Sound in south-central Alaska (Cooper and Cytyk 2000). The debated *A. g. apache*, as recognized, is found from southern Arizona south to Jalisco in the mountains of Mexico (van Rossem 1938).

*General species description*

The largest and heaviest bodied of the three North American accipiters, goshawks have long, broad wings, a long, rounded tail, and stout legs and feet (Palmer 1988, Squires and Reynolds 1997). The Eurasian gentilis subspecies is larger in size and body weight than any of the three North American subspecies. Although females are larger than males, goshawks are less dimorphic than smaller North American accipiters (Storer 1966). Average total length is 55 cm for males and 61 cm for females (Wood 1938). Reported averages for males range from 98–104 cm for wingspans and 631–1,099 g in mass, and for females from 105–115 cm for wingspans and 860–1,364 g in mass (Wheeler and Clark 1995, Squires and Reynolds 1997). The wingtips do not extend to the tail's midpoint when perched (Johnsgard 1990).

In adult plumage (Squires and Reynolds 1997), dorsal markings are brown-gray to slate gray, sometimes bluish. The head has a distinctive white superciliary line separating a black cap from the whitish sides of the crown. The iris is dark red to mahogany (Palmer 1988, Johnsgard 1990). Underparts are uniformly whitish to pale gray with fine horizontal vermiculations and variable darker gray streaks on the lower breast, abdomen, and tibiae, which tend to appear as coarser barring on females. Adult females may also appear more brownish above. The tail is gray with three to five broad, dark bands, which are narrower than the intervening lighter gray bands. The tail tip is rounded and has a thin white terminal band. Undertail coverts are white and may be fluffed out during courtship displays or when the bird is alarmed. The bill and claws are bluish gray to black and the cere, tarsi, and toes are yellow.

Juvenal plumage (Palmer 1988, Johnsgard 1990, and Squires and Reynolds 1997) begins to emerge by about 17-18 days of age and is mostly complete when the bird has fledged. This plumage is retained through the first winter until it molts into its Basic I plumage. In the juvenal plumage, upperparts are dark brown to brown-black. The underparts and wing-linings are buffy white with coarse cinnamon to black-brown streaking on the throat. The dark brown tail has wavy dark brown bands with thin whitish borders that form a zigzag pattern and the undertail-coverts are usually streaked and not fluffy. The head is brown and has a pale whitish superciliary stripe and pale yellow irises, turning bright yellow during the first year, and becoming orange during the second year before turning red as adults. Tarsi and toes are greenish-gray to pale yellow.

In comparison to other North American accipiters (Wheeler and Clark 1995, Squires and Reynolds 1997), goshawks appear deep-chested with relatively broad wings, short tail, and smaller eye. Their wings appear tapered when soaring and pointed when flapping or stooping. They are recognizably larger than sharp-shinned hawks (*Accipiter striatus*), with a more protruding head in flight and a broader tail that is more rounded at the tip. Although female Cooper's hawks (*A. cooperii*) may approach the size of male goshawks, distinctions can be made in the body, wing, and tail proportions described above. Also, the tarsus of the Cooper's hawk is feathered to only one half its length, while the goshawk's is stouter and feathered to two-thirds its length (Brown and Amadon 1968).

In juvenal plumage, the goshawk can be difficult to distinguish from the Cooper's hawk. The pale superciliary line is more distinctive in juvenile goshawks and they are more heavily streaked in the belly, underwing, and under-tail coverts, with a slightly wedge-shaped tail, and a tawny bar across the upperwing. Also, the upperside of a juvenile goshawk's tail has a subtle pattern of fine white lines outlining the dark bands, which, when spread, appear as staggered dark bars in a zigzag pattern. In contrast, the tail of a juvenile Cooper's hawk appears more evenly banded (Wheeler and Clark 1995, Squires and Reynolds 1997).

## Distribution and abundance

### *North American distribution*

Northern goshawks are holarctic (**Figure 3**) and occupy a wide variety of boreal and montane forest habitats throughout the Nearctic and Palearctic (Johnsgard 1990). *Accipiter gentilis atricapillus* breeds in North America from boreal forests of north-central Alaska to Newfoundland and south to western and southwestern montane forests in the United States, and locally in the mountains of northwestern and western Mexico (**Figure 4**). To the east, it is found in the western Great Lakes region and eastward to Pennsylvania, central New York, northwestern Connecticut, and locally south in montane habitats at least to West Virginia and possibly eastern Tennessee and western North Carolina (Brown and Amadon 1968, Squires and Reynolds 1997, USFWS 1998b). Factors that limit the southern extent of goshawk range are unknown (Kennedy 1997). *Accipiter gentilis atricapillus* is known to winter throughout its breeding range and as far south as southern California, northern Mexico, Texas, and the northern portions of the Gulf states, rarely including Florida (Johnsgard 1990, Squires and Reynolds 1997).

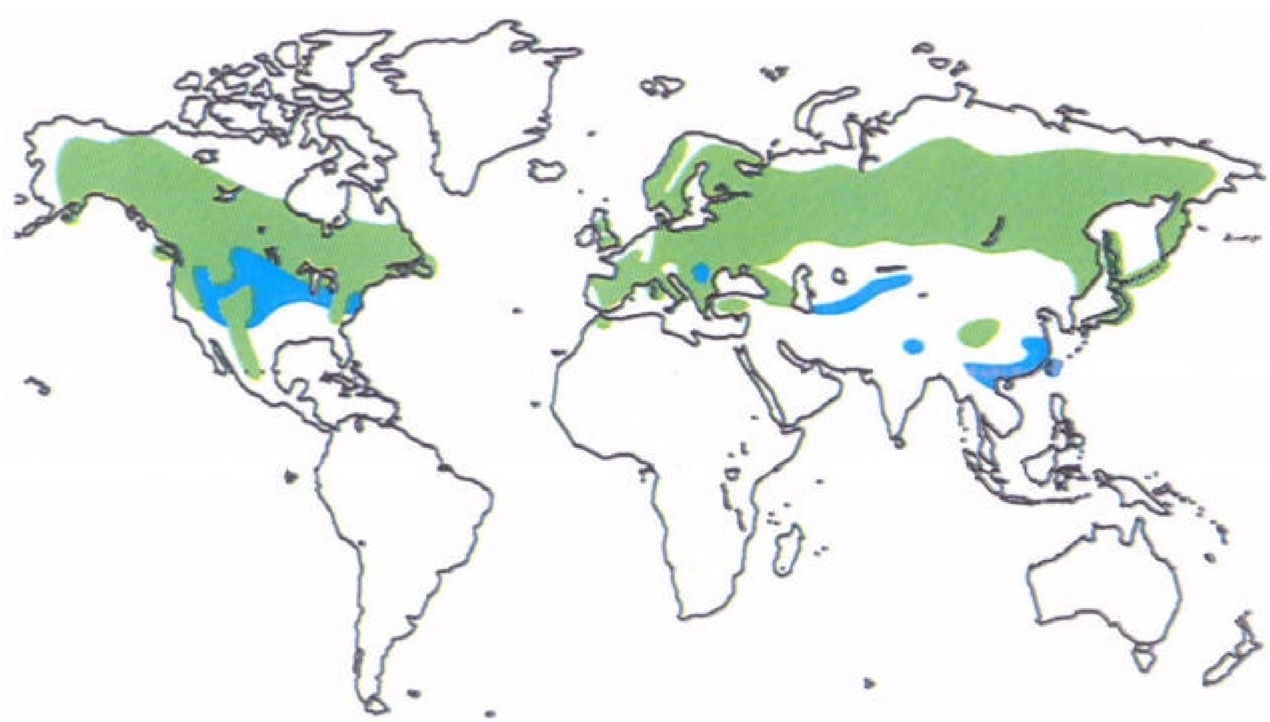

**Figure 3.** Global distribution of the goshawk, *Accipiter gentilis*. Green indicates areas where the species tends to be present year-round. Blue indicates areas occupied by goshawks outside the breeding season or areas where breeding has not yet been documented (from del Hoyo et. al., 1994).

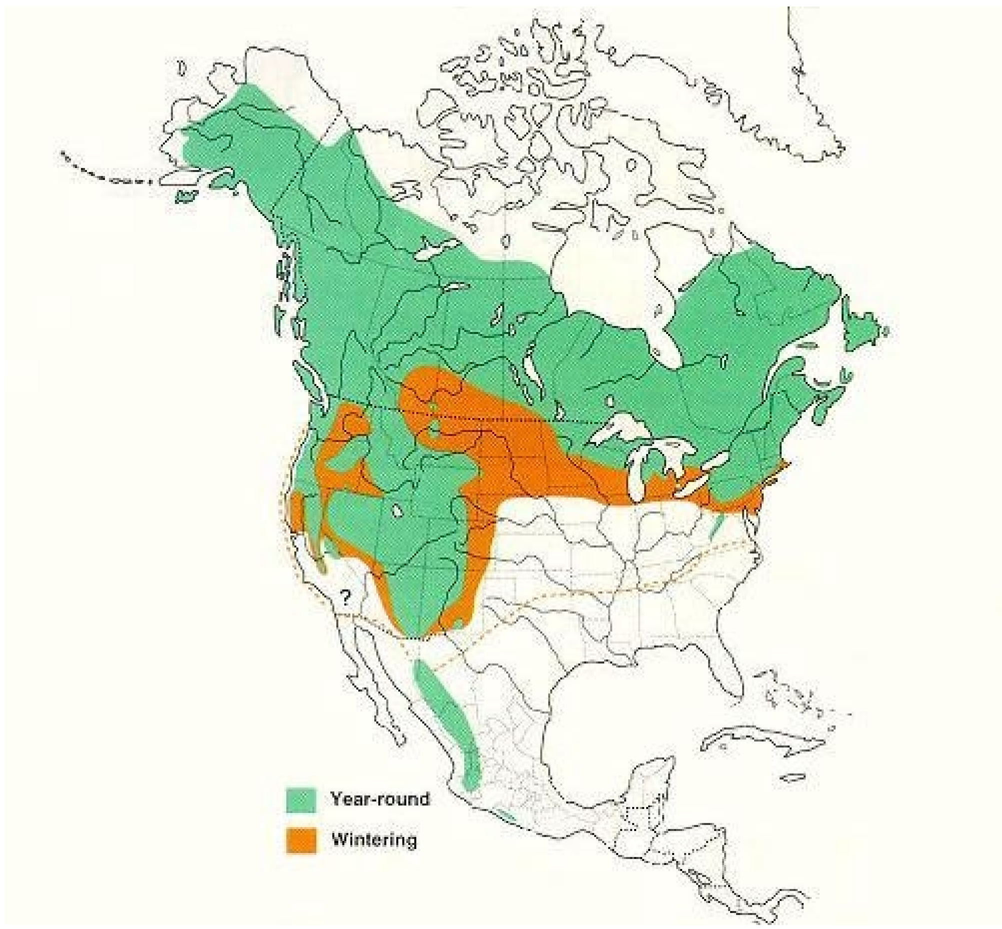


**Figure 4.** Distribution of the northern goshawk in North America.

Although there are few data regarding historical changes, Squires and Reynolds (1997) suggested the distribution of the goshawk in the northern and western portions of its range is relatively unchanged since Europeans settled North America. However, the goshawk's range may have been more extensive in the eastern U.S. before the extinction of the passenger pigeon in the early 1900s, because the pigeon may have been an important prey item. The goshawk's range may also have been more extensive before the extensive deforestation of this region, which reached a peak at the end of the 19th century (Kennedy 1997). There is some evidence that these populations may be recovering as forests re-establish and mature (Speiser and Bosakowski 1984, Kennedy 1997). For example, during the mid-1950s in Massachusetts, nesting was restricted to the western part of the state, but the species now nests throughout the state (Veit and Petersen 1993). In Minnesota, the bird was formerly restricted to the southeastern region, but apparently is expanding northward and westward into east-central, central, northeastern and north-central regions (Janssen 1987, Roberson et al. 2002). Evidence that eastern goshawk populations may be expanding or reoccupying their former range should be interpreted cautiously; such reports could merely reflect increased search effort (Kennedy 1997).

*Region 2 distribution*

There are no published accounts on the distribution and abundance of goshawks in Region 2. I used two approaches to predict its regional distributions. The first approach was a simple summary of the confirmed goshawk observations within the region, including a coarse-grained description of the habitat types associated with the observations (described in detail in Habitat section). The second approach was to summarize the GAP Analyses that have been done by the states within the region. I also evaluate the utility of both approaches. An analysis of BBS data was not included because there are too few goshawk sightings on BBS routes within the region.

**Sighting data:** For Colorado, Kansas, Nebraska and South Dakota, I compiled sighting evidence from the periodicals of state ornithological societies by date and county. Wintering occurrences included all observations made between December and early February, while breeding occurrences consisted of all observations from mid-March to September. Fall and spring migration included all sightings made in October and November and mid-February to mid-March, respectively. The county of sighting was determined directly from the literature or indirectly from the sighting location. An estimate of the forest type for each sighting was determined, and this will be discussed in more detail in the Habitat section. Maps depicting winter and breeding distribution by county were created and are presented in **Figures 5-8**. I caution that this is a coarse-scale analysis, which may be subject to overestimation of the regional range.

Limited sighting data exist for the state of Wyoming. Our only source of data was the 1999 Atlas of Birds, Mammals, Reptiles and Amphibians in Wyoming (Luce et al. 1999). The atlas created one-degree latitude by one-degree longitude rectangles as distribution description blocks. Each block was categorized as: B - Confirmed breeding (nest or dependent young observed); b - Potential breeding ("circumstantial evidence of nesting"); and O - Other than breeding (species observed but no nesting evidence recorded). The distribution map generated from these sightings is presented in **Figure 9**.

The following sections detail the goshawk's winter and breeding distributions based on **Figures 5-9**. When considering these data one should refer to all sightings with caution since the training and accuracy of the observers are unknown. Since I relied on individual observations to include whole counties in the goshawk's distribution maps, winter and breeding ranges are probably overestimated.

*Colorado:* According to data collected from 1992-2001 by the Colorado Field Ornithologists (CFO) the goshawk has a year-round occurrence in Colorado (Hill 1993, Leatherman 1996-1995, and Melcher 1999-1997, Gillihan 2000). However, the type of data recorded by the CFO was problematic for my analysis. Not all accounts provided exact dates, and field reports spanned over a period that included more than one seasonal category. Thus, it was hard to classify the season for some sightings. Therefore, I decided to apply a conservative approach and delete all entries that were ambiguous. These deletions comprised nine winter/ spring migration entries, three breeding / fall migration entries, and one spring migration/breeding entry, for a total of 13 entries. An almost identical number of sightings occurred in the winter (52 sightings) and breeding seasons (58 sightings). Because many of the CFO sightings are from Christmas Bird Counts (CBC) the number of reported winter sightings relative to other seasons is inflated.

Based on sighting data prior to 1992, Andrews and Righter (1992) found the goshawk distributed across the western half of Colorado during summer, and across all of the state during the winter and migration periods. This pattern is supported by my analysis of the recent sighting data, which show the goshawk's breeding distribution to be primarily west of 1050 longitude (**Figure 5**). In addition, the CFO data indicate confirmed breeding sightings occur in the western half of the state with wide winter distribution across all of Colorado (**Figure 5**). However, Shuster (1976, 1980) studied breeding goshawks in eastern Colorado in the 1970s at nest sites in Larimer County near Fort Collins and in Rocky Mountain National Park, CO. Although sightings have not been recorded in Larimer County by CFO, the goshawk probably breeds in all areas of the state with forested habitat.

According to CFO, winter sightings occurred in the following counties: Adams, Alamosa, Arapahoe, Baca, Boulder, Clear Creek, Denver, Douglas, Eagle, El Paso, Garfield, Jefferson, La Plata, Larimer, Mesa, Montrose, Otero, Pitkin, Pueblo and Weld. Counties with confirmed breeding occurrence included: Eagle, Grand, Jackson, Jefferson, La Plata, Montrose, Pitkin and Rio Grande, while the counties of Bent, Chaffee, Gilpin, Las Animas, Montezuma, Park and Rio Blanco included breeding occurrence only (**Figure 5**). Eight counties (**Figure 5**) have recorded goshawks year-round.

*Kansas:* Sighting evidence compiled by the Kansas Ornithological Society from 1989-2001 suggests the goshawk frequents Kansas mainly during fall and winter. Some occurrences of the species in early and late April may suggest breeding activity, however they may also represent delayed spring migration (Anonymous 1990-1993, Otte 1994-2001). The lack of breeding evidence is further supported by the lack of a species account in the recently published Kansas Breeding Bird Atlas (Busby and Zimmerman 2001). Since there are no confirmed nesting and/or breeding records of the goshawk in Kansas, those counties where sightings occurred during the breeding period are classified as potential breeding occurrences (**Figure 6**). Winter sightings occurred in the following counties: Morton and Stanton counties to the southwest; Cowley, Ellsworth, Harvey, Lincoln, Mitchell, Norton, Pawnee, Russell and Sedgwick in the central portion of the state; and Douglas, Geary, Jefferson, Johnson, Osage and Riley to the east (**Figure 6**). Potential breeding sightings occurred in the following counties: Cheyenne, Cowley, Douglas, Gove, Harvey, Jefferson, Morton, Norton, Pawnee, Riley, Russell, and Sedgwick, Stafford and Stevens.

*Nebraska:* All goshawk occurrences reported by the Nebraska Ornithologists' Union Inc. (NOU) during 1992-2000 occurred during fall migration or winter (Morris 1992-1997, Clements and Klubertanz 1998, Clements 1999-2000). Winter sightings occurred in the following counties: Scottsbluff to the outmost west; Keith, Lincoln, and Perkins in the central-west portion of the state; Buffalo, Greeley, Hall, Sherman and Wheeler in the central-east portion; and Cass, Douglas, Knox, Lancaster, Madison, Saunders and Seward counties in the eastern parts of Nebraska (**Figure 7**).

*South Dakota:* According to data compiled from the South Dakota Ornithologists' Union (SDOU) between the years 1992 and 2001, the goshawk occurs year-round in South Dakota (Tallman 1992-2001). About two-thirds of all observations reported occurred during the winter season and include the following counties: Custer, Fall River, Lawrence, Meade, Pennington, Perkins to the west; Bennett, Edmunds, Faulk, Gregory, Hughes and Jones in the central portion of the state; and Bon Homme, Brookings, Brown, Charles Mix, Codington, Day, Deuel, Lake, Lincoln, Roberts, and Yankton to the east (**Figure 8**). Breeding occurrences include Brookings, Custer, Lawrence, Meade, Mellette and Pennington Counties. This geographic pattern is

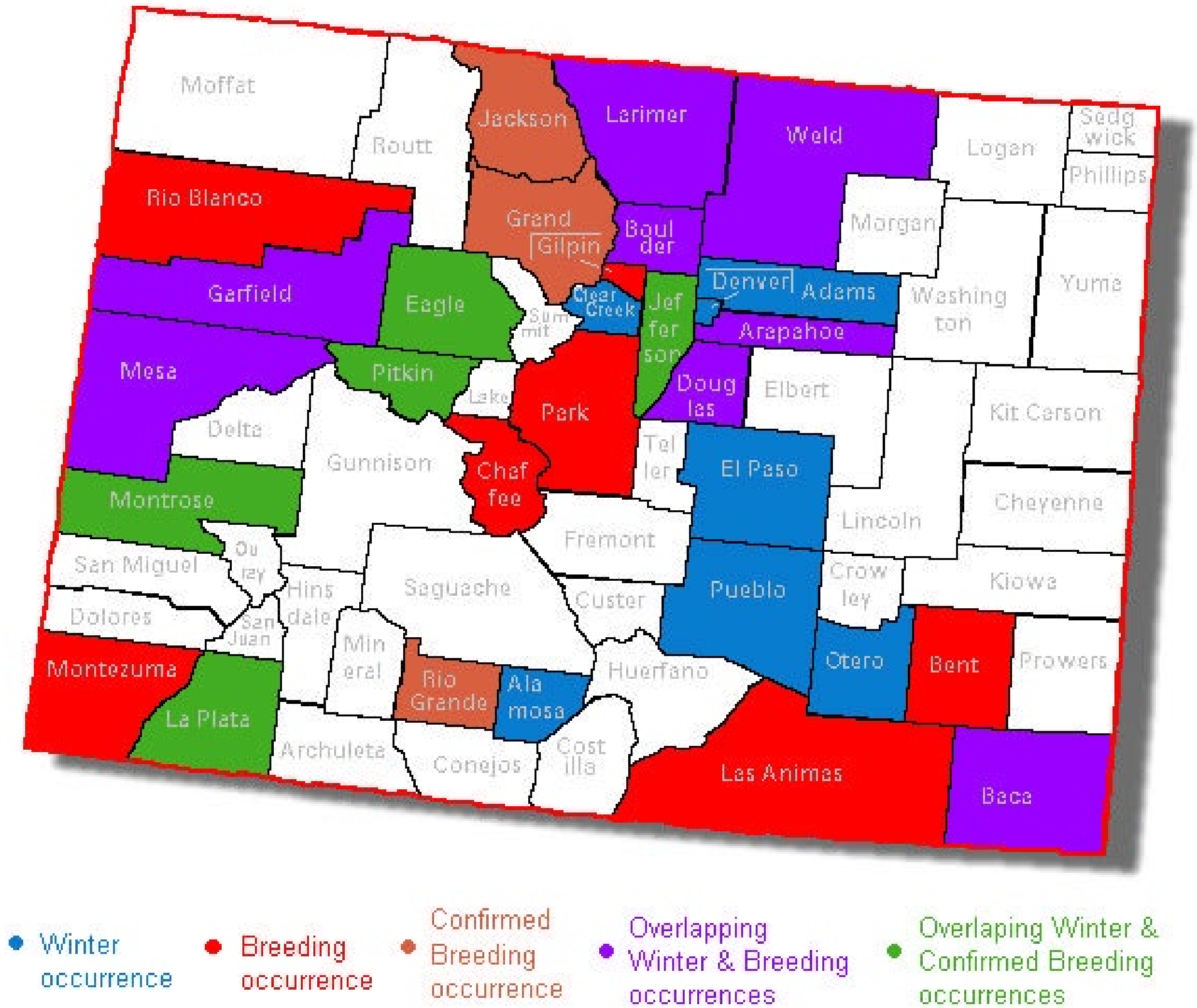


**Figure 5.** Winter and breeding occurrences of the northern goshawk in Colorado (data adapted from the Colorado Field Ornithologists: Gillihan 2000, Hill 1993a, 1993b, Leatherman 1995a, 1995b, 1996a, 1996b, 1996c, and Melcher 1997a, 1997b, 1997c, 1997d, 1998a, 1998b, 1998c, 1998d, 1999a, 1999b, 1999c).

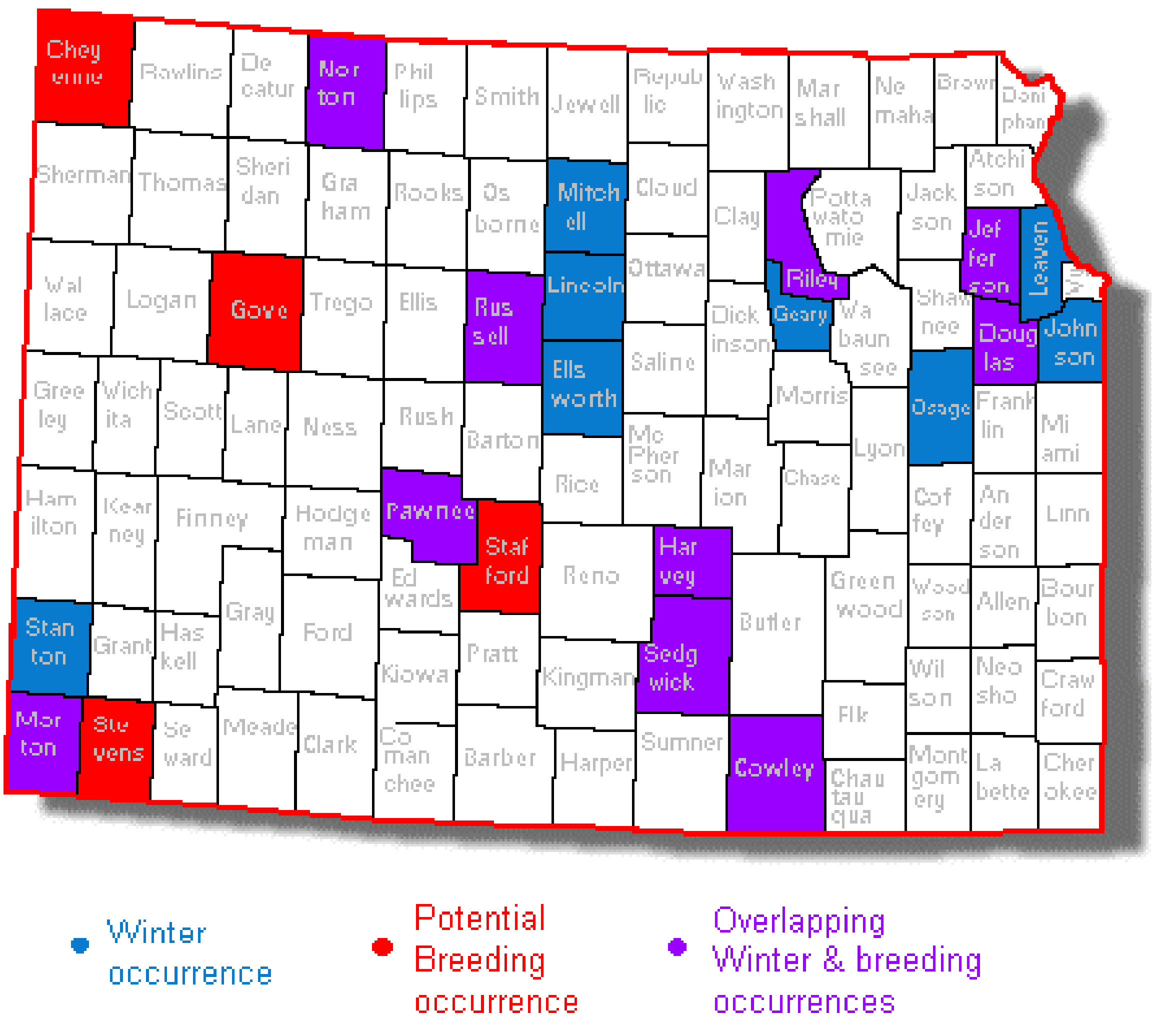


**Figure 6.** Winter and breeding occurrences of the northern goshawk in Kansas (data adapted from the Kansas Ornithological Society: Anonymous 1990, 1991a, 1991b, 1992a, 1992b, 1992c, 1993a, 1993b, Otte 1994a, 1994b, 1994c, 1995a, 1995b, 1995c,1996, 1997a, 1997b, 1997c, 1998a, 1998b, 1998c, 1999a, 1999b, 2000a, 2000b, 2001a, 2001b).

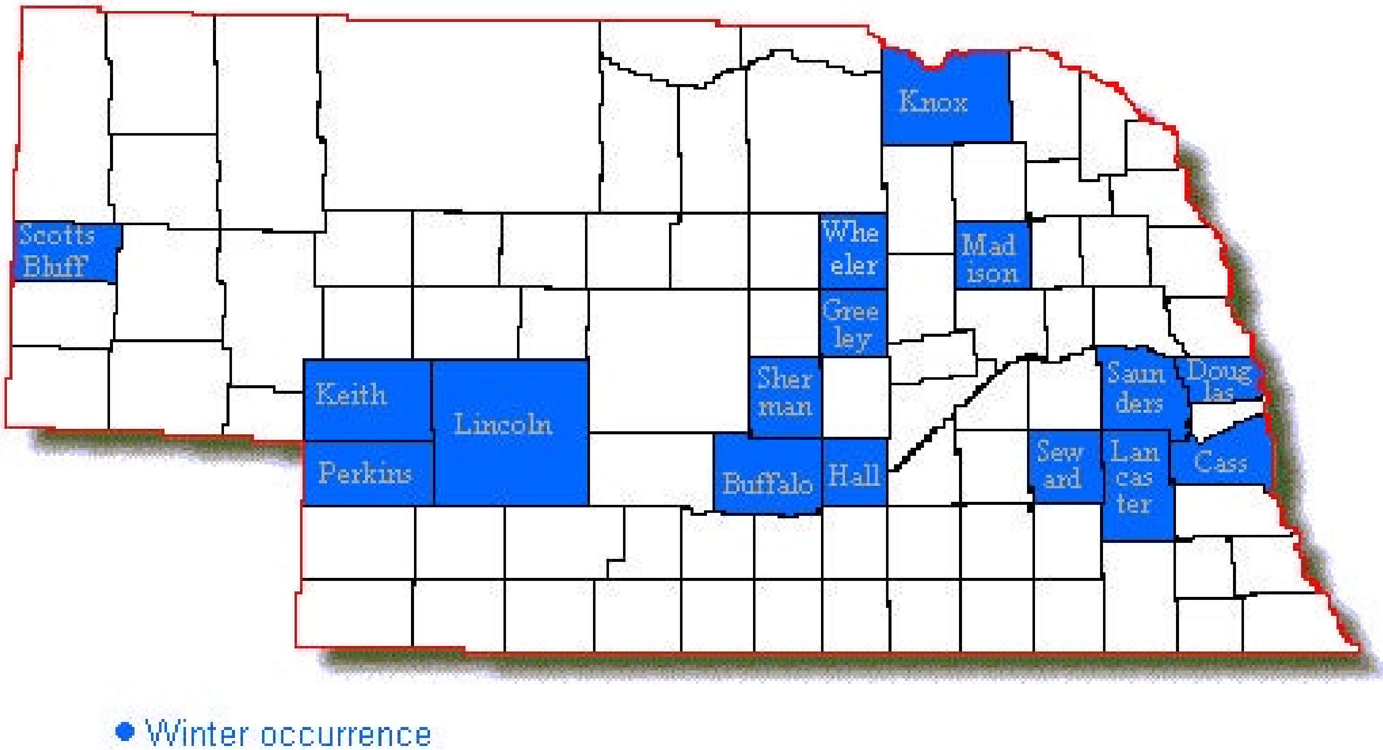


**Figure 7.** Winter occurrence of the northern goshawk in Nebraska (data adapted from the Nebraska Ornithologists' Union: Clements 1999a, 1999b, 2000a, 2000b, Clements and Klubertanz 1998, Morris 1992, 1993, 1994, 1995a, 1995b, 1996, 1997). No current breeding records exist for this state.

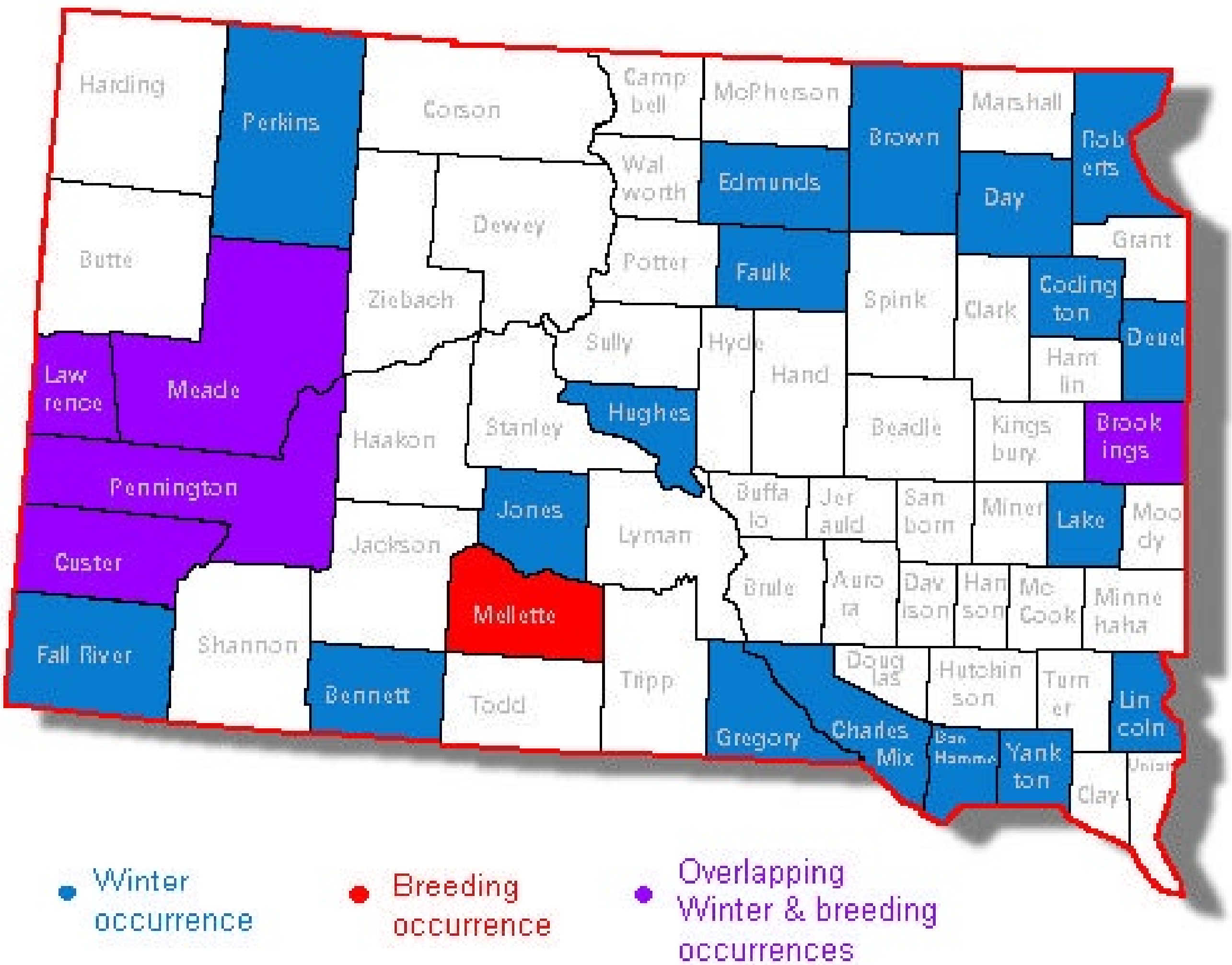


**Figure 8.** Winter and breeding occurrences of the northern goshawk in South Dakota (data adapted from the South Dakota Ornithologists' Union: Tallman 1992a, 1992b, 1992c, 1993a, 1993b, 1993c, 1994a, 1994b, 1994c, 1995a, 1995b, 1995c, 1995d, 1996a, 1996b, 1996c, 1997a, 1997b, 1997c, 1998a, 1998b, 1998c, 1998d, 1999a, 1999b, 1999c, 1999d, 2000a, 2000b, 2000c, 2000d, 2001a, 2001b).

supported by an absence of overlap between winter locales of SDOU observations and CBC sightings. However, bias in sampling effort across seasons as a result of the CBCs may have inflated the number of reported winter sightings.

Few confirmed breeding reports were made during the summers of 1994 and 1995 in Custer, Meade, and Pennington counties (Tallman 1994-1995). However, data from Peterson (1995) indicate the goshawk uses the central-west and southwest portion of the state as breeding grounds. Peterson (1995) suggests these findings are based on extensive survey work by Black Hills National Forest personnel. Peterson's comment illustrates the potential bias that occurs in all of these distributions due to inconsistent efforts in nest searching.

*Wyoming:* According to Luce et al. (1999) the goshawk breeds, attempts to breed, or is observed in almost all of the lat long grid blocks in Wyoming. The only block currently unoccupied by the bird occurs in the eastern portion of the state, and covers most of Weston County as well as northern Niobrara County (**Figure 9**).

**Predictions of goshawk distribution - GAP analyses:** Gap analyses use Geographic Information Systems (GIS) techniques to combine data on natural history and habitat associations of species with existing habitat conditions, to predict species distribution and identify gaps in conservation management. According to Merrill (1996), "[GAP analysis should] provide a management framework for designing further field surveys and research projects toward improving our understanding of species distributions." Scott and Jennings (1997 *in* http://www.gap.uidaho.edu/About/Overview/GapDescription/default.htm) claim that unlike threatened and endangered species, relatively common species often receive lower conservation priorities, thus data about the latter is often lacking. GAP projects attempt to centralize contemporary information for all species (with a current emphasis on vertebrates), and allow managers to assess species conservation at broad spatial extents (Scott and Jennings 1997). Although GAP is a coarse-scale analysis and has many limitations (described in the next section), it provides managers with readily accessible information, which is visually presented.

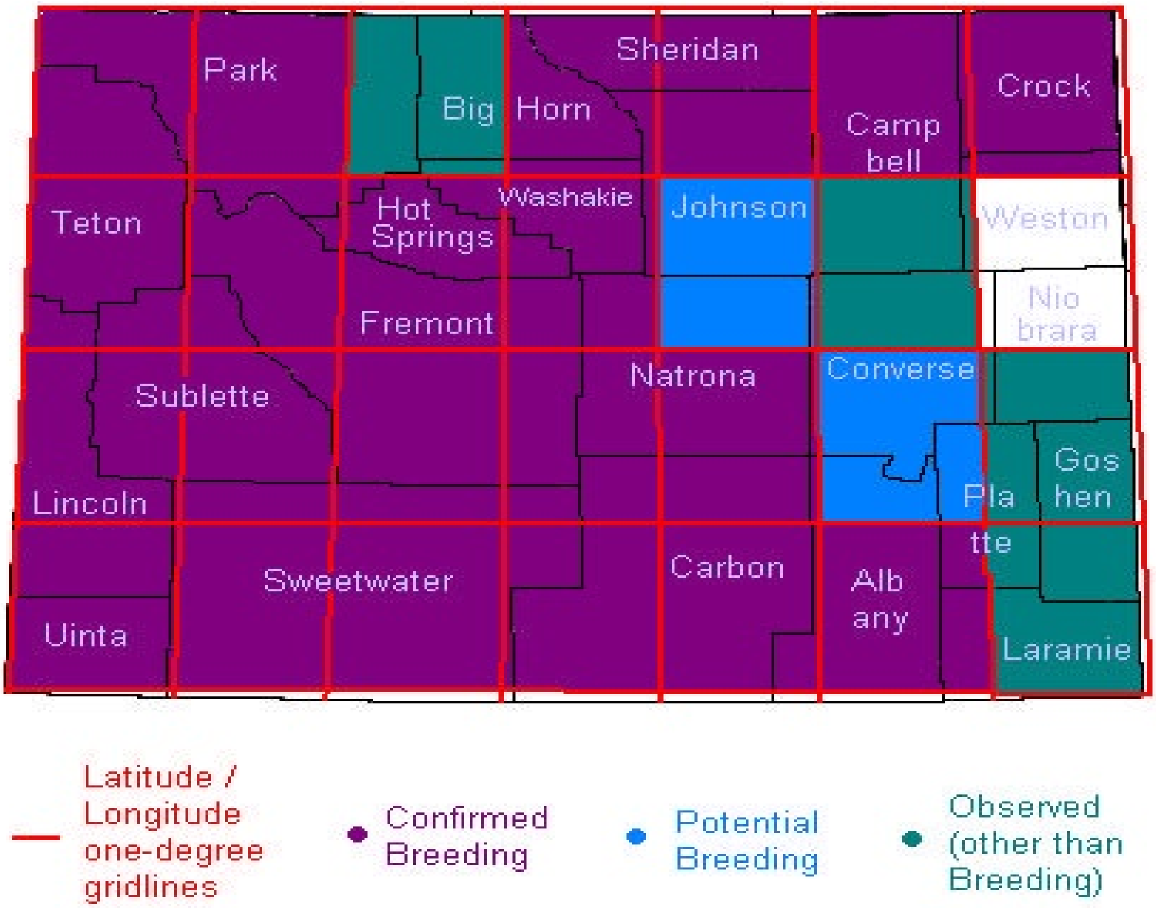


**Figure 9.** Northern goshawk occurrence in Wyoming (data adapted from the Atlas of Birds, Mammals, Reptiles and Amphibians in Wyoming, Luce et al. 1999).

GAP analyses for many vertebrate species have been done for Colorado and Wyoming. GAP projects for the states of Kansas, Nebraska and South Dakota are still under development, and were not completed in time to incorporate into this assessment. The GAP predictions of northern goshawk distribution in the states' cover-types and the conservation implications follow each methodology section.

*General GAP methodology:* Predicted species distributions are estimated in GAP by first mapping vegetative cover using satellite imagery and GIS software to determine the distribution of vegetation cover-types in the area of interest. Predicted species distribution is determined by combining species occurrence records with habitat affinity information for the state. Using the predicted distribution, a land ownership and management practices layer is developed to assess the cover of protected areas and extent of this protection for each particular cover-type within each species range. Procedures for Wyoming GAP (WY-GAP) are summarized in Merrill (1996) and Schrupp (2000) summarizes procedures for Colorado GAP (CO-GAP). One big difference in the two methodologies is that WY-GAP uses a global hexagon system for mapping goshawk occurrence (resulting in smaller mapping units and borders that are independent of political and administrative units) and CO-GAP uses a county-based approach.

*Wyoming GAP:* The most common cover-types occurring in the predicted goshawk distribution are Wyoming big sagebrush (*Artemesia tridentate wyomingensis*) and lodgepole pine (*Pinus contorta*) (comprising 37.1% and 15.2% of all primary cover types in which the goshawk occurs, respectively; **Figure 10**, **Table 3**). Most common secondary cover-types consist of Wyoming big sagebrush and forest-dominated riparian (57.7% and 8.1% of all secondary cover-types, respectively). Lands with conservation status of 1 or 2 (conservation ranks range from 1-4 with 1 designating the most permanent and comprehensive management promoting biodiversity maintenance and 4 designating the least, or unknown status of biodiversity maintenance) consisted of 17.6% of the total goshawk predicted range (**Table 4**). The most common primary cover-types for goshawks, Wyoming big sagebrush and lodgepole pine respectively, have 0.6% and 38.7% of total land cover under conservation status 1 or 2. Despite the fact that lodgepole pine has <50% of all land cover under status 1 and 2, this cover-type is considered widespread in Wyoming, and according

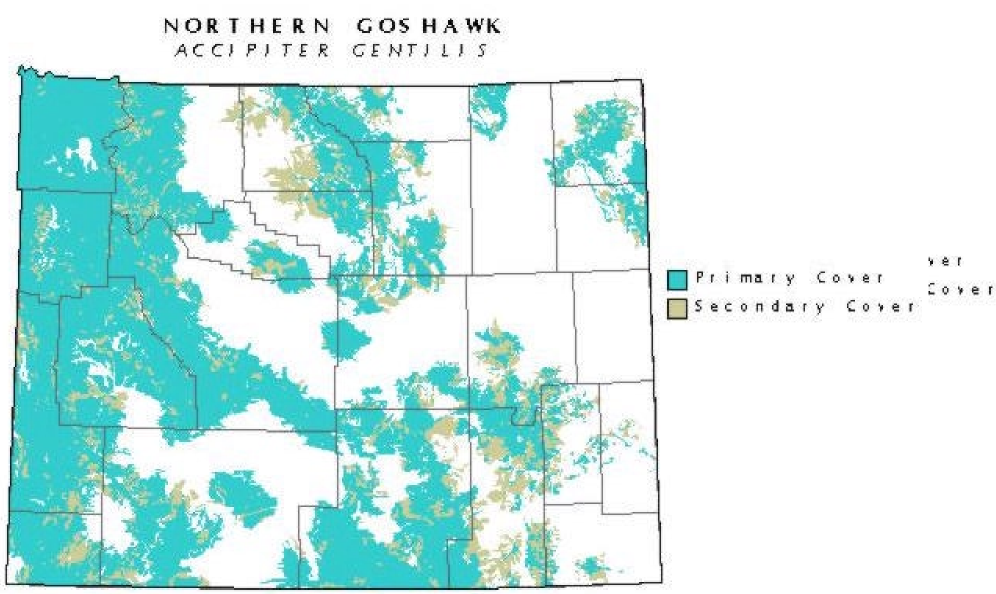


**Figure 10.** Predicted occurrence of the northern goshawk in Wyoming and cover-type abundance classification of these lands based on 1996 Wyoming Gap (WY-GAP) analysis.

**Table 3.** Status and ownership of most common primary and secondary cover-types in areas of northern goshawk predicted distribution in Wyoming.

| Cover-type | Classification in goshawk predicted range | % area in goshawk predicted range | % area in status 1 or 2 (total for state) | Ownership in which most area occurs |
|---|---|---|---|---|
| Wyoming big sagebrush | Primary | 37.1 | 0.6 | Federal (50.4%) |
| Lodgepole pine | Primary | 15.2 | 38.7 | Federal (91.3%) |
| Wyoming big sagebrush | Secondary | 57.7 | 0.6 | Federal (50.4%) |
| Forest-dominated riparian | Secondary | 8.1 | 6.3 | Private (75.1%) |

**Table 4.** Area of primary and secondary cover types in the Wyoming northern goshawk range as predicted by the Wyoming GAP analysis. (Adapted from http://www.sdvc.uwyo.edu/wbn/atlas/info/abnkc12060.html).

| Cover types | Area of primary cover-type (ha) | Area of secondary cover-type (ha) |
|---|---|---|
| Spruce-fir | 188,654 | 14,975 |
| Douglas fir | 149,115 | 3,862 |
| Lodgepole pine | 640,000 | 12,018 |
| Whitebark pine | 28,784 | 824 |
| Limber pine woodland | 49,527 | 9,203 |
| Ponderosa pine | 222,935 | 49,076 |
| Juniper woodland | 166,773 | 17,611 |
| Clearcut conifer | 40,054 | 44 |
| Burned conifer | 112,425 | 405 |
| Aspen | 108,028 | 8,610 |
| Bur oak woodland | 4,073 | 4,347 |
| Forest-dominated riparian | 75,259 | 78,373 |
| Mountain big sagebrush | 329,331 | 59,802 |
| Wyoming big sagebrush | 1,564,801 | 557,216 |
| Shrub-dominated riparian | 71,197 | 43,652 |
| Meadow tundra | 31,157 | 44,250 |
| Subalpine meadow | 262,905 | 48,650 |
| Grass-dominated wetland | 9,019 | 3 |
| Grass-dominated riparian | 4,347 | 2,621 |
| Dryland crops | 17,402 | 12,371 |
| Unclassified riparian | 143,456 | 0 |
| Total | 4,219,242 | 967,913 |

**Table 5.** Cover-types found in the northern goshawk range in Colorado predicted by Colorado Gap Analyses (adapted from http://ndis1.nrel.colostate.edu/cogap/habaffin/tables/h040221.htm)

| **Urban & Croplands** | **Riparian Wetlands** |
|---|---|
| Urban | Forested Wetlands |
| Dryland Crops | Shrub Dominated Wetlands |
| Irrigated Crops | Grass/Forb Dominated Wetlands |

| **Grasslands** | **Shrublands** | **Forestlands** |
|---|---|---|
| Foothill/Mountain Grassland | Mesic Upland shrub | Deciduous Forest - General |
| | Xeric Upland Shrub | Aspen Forest |
| | Deciduous Oak | Coniferous Forest - General |
| | Bitterbrush Shrub | Spruce-Fir |
| | Mountain Big Sage | Spruce-Fir - Clearcut/Logged |
| | Big Sagebrush Shrubland | Douglas Fir |
| | Desert Shrub | Lodgepole Pine |
| | | Lodgepole Pine - Clearcut/Logged |
| | | Limber Pine |
| | | Ponderosa Pine/Lodgepole |
| | | Blue Spruce |
| | | White Fir |
| | | Juniper |
| | | Pinyon-Juniper Rocky Mountain |
| | | Bristlecone Pine |
| | | Mixed Conifer |
| | | Mixed Conifer - General |

| **Tundra** | **Unvegetated** |
|---|---|
| Meadow Tundra | Exposed Rock |
| Subalpine Meadow | Strip Mines/Quarries |

to WY-GAP, the main concern is to maintain its structural characteristics by means of fire. Wyoming big sagebrush cover type is also considered widespread in Wyoming and the surrounding states, yet events such as grazing, fire regimes, exotic invasions and oil and gas development may alter this cover type's structure and function. WY-GAP cautions about under-estimating cover-type status especially of Wyoming big sagebrush, which occupies about half of Wyoming's lands.

The most common secondary cover-types are Wyoming big sagebrush and forest- dominated riparian habitat, with the riparian habitat having 6.34% of all land cover under conservation status of 1 or 2 (**Table 4**). Forest-dominated riparian habitat is 75% under private management (**Table 3**). Although its conservation status is potentially underestimated because management information was hard to obtain for private lands, WY-GAP identifies the forest-dominated riparian cover-type as one of three types that should receive highest conservation priority.

*Colorado GAP:* Unlike WY-GAP, CO-GAP does not provide a comprehensive breakdown of the area occupied by each cover-type classification (i.e. - primary or secondary). **Table 5** is a list of all cover-types included under the predicted goshawk range in Colorado. According to CO-GAP, 10 - 20% of the goshawk's predicted distribution is in lands with status 1 or 2 (**Figure 11**). Since no information exists on cover-type areas in the goshawk range, it is hard to estimate what management practices pose the greatest risk. CO-GAP claims that most bird species with 10-20 % of their range under management status 1 or 2 will benefit from increased conservation priorities for open water and riparian habitats. It is unclear how applicable

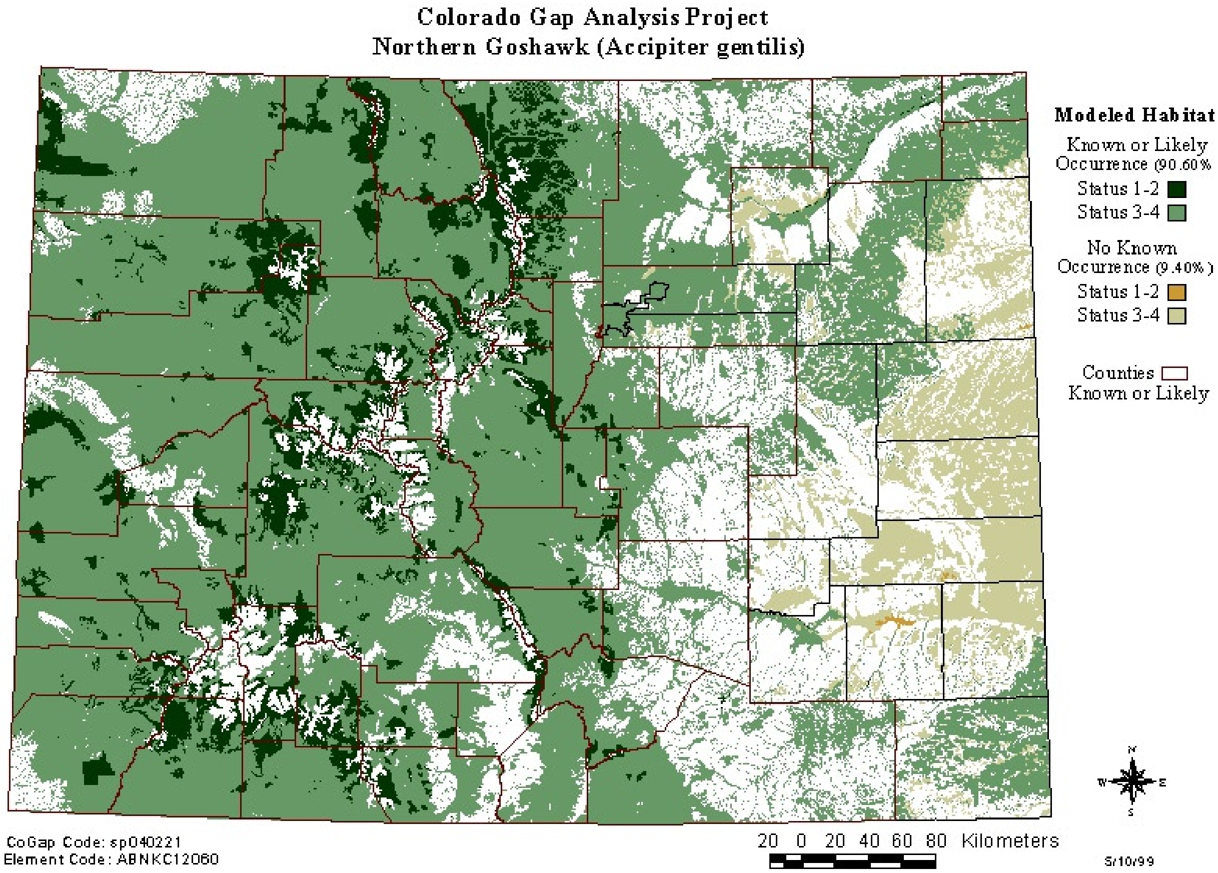


**Figure 11.** Occurrence classification of the northern goshawk in Colorado and management status of these lands based on CO-GAP analysis. Goshawk occurrence was estimated using a county-level approach where county-level goshawk sightings (known occurrence) are combined with potential habitat affinities (likely occurrence).

this statement is to the goshawk. Lastly, CO-GAP did acknowledge limitations involved with habitat mapping, including the lack of micro-habitat mapping and habitat quality considerations (versus availability only).

*Limitations of GAP analyses:* GAP analysis has been criticized in the literature because this type of habitat modeling may fail to address issues such as species interactions (i.e., co-occurrence or avoidance), effects of spatial and temporal arrangement of habitats on species distribution, and long-term sustainability of the focal species (Hansen et al. 1999, Flather et al. 1997). Flather et al. (1997) emphasize that GAP is a static representation of ecological conditions, and involves an inherent assumption that ecological processes are contained within the "pattern-defined boundaries" such as vegetation cover-types. Additionally, species presence/absence data often used by GAP does not reflect the species abundance in these areas, or the quality of habitat to sustain species survival and reproduction (Hansen et al. 1999, Flather et al. 1997). Lastly, errors in the original databases and the GAP process should be incorporated into the GAP analyses (Dean et al. 1997).

Flather et al. (1997) categorize these potential errors as: "Gross errors, such as recording errors or misidentification; systematic errors, such as instrument imperfections; and random errors, due to natural variation and sampling." Dean et al. (1997) used Monte Carlo simulations to examine the variation in the distribution of 10 rodent species in Oregon as a result of propagation of errors of omission and commission (ranged from 5-20% in their simulations). They found that the GAP predictions were very sensitive to these errors. They recommend that error modeling should be included in GAP analyses before spatially explicit conservation recommendations are made. Although

CO-GAP and WY-GAP report their errors and speculate as to the source of these errors, they do not appear to incorporate these errors into their analyses. Incorporation of error modeling or sensitivity analyses into these GAP analyses seems essential; otherwise users of **Figure 10** and **Figure 11** will be unaware of the uncertainty associated with these maps.

The utility of the two maps produced by WY-GAP and CO-GAP is that they generate a hypothesis about the statewide distributions of the goshawk. However, as with any untested hypothesis, the predictions generated by these maps need to be tested with more information on state-specific habitat affinities and presence/absence data. The overall accuracy of the CO-GAP project (31%) suggests this map is in need of additional data at smaller spatial scales before it can be used by a manager. The overall accuracy of WY-GAP (79.5%) was close to the national standard (80%) but its predictions are difficult to interpret. For example, WY-GAP predicts that Wyoming sagebrush is an important habitat type for goshawks. The species might use this habitat as an ecotone with forest cover types during the winter but it does not nest in non-forested habitat and its winter habitat affinities are not documented at any location in its range. In addition, the absence of structural stage information limits the utility of this map to a manager. The bird probably uses all of the predicted forest communities but it will probably not be found in all seral stages. These results illustrate the problems associated with GAP analyses when they are not based on sound habitat-relationship models (Dean et al. 1997). Without additional data on winter habitat affinities and breeding season seral stage use in the forest cover types, the utility of the Wyoming map is limited to hypothesizing potential statewide range boundaries in Wyoming.

Region 2 could assist with this process by summarizing all of the goshawk sighting information collected on the district as follows: 1) sighting location; 2) date and time of sighting; 3) cover type; and 4) seral stage. This summary could then be provided to CO-GAP and WY-GAP for modification of their maps.

**Habitat analysis of sighting data for Kansas, Nebraska and South Dakota:** As indicated in the previous section, GAP analyses are not available for Kansas, Nebraska and South Dakota. In addition there is little published information on goshawk habitat use in these states. As a first cut at identifying potential goshawk habitat in these states I did a very coarse-grained analysis of the potential habitat associated with the sightings in these states, which are described in the section on Region 2 distribution.

Unfortunately, habitat type information is not available for the sightings. Thus, I assigned a potential habitat type to each sighting using USFS inventory analysis reports for the three states (Leatherberry et al. 1999, Leatherberry et al. 2000, Schmidt and Wardle 1998). These reports present the results of forest inventories within each state. I used the reported coverage in hectares (rounded to the nearest hundred) of each forest type within each survey unit to calculate its relative cover of the total forested area. The hectares of dominant forest types were assigned as the forest types for the sightings. These dominant forest types include: eastern red cedar, elm-ash-cottonwood, elm-ash locust, oak-hickory, and ponderosa pine. **Tables 6-8** provide a list of associated species found in each of the dominant forest types in each state. Readers should note that according to the USFS classification each forest type is composed of several sub-types. Although my analysis relied on the sum of all sub-types as the total area by forest type, I present the full list of associated species by sub-types as published in the inventory reports.

The following sections present the predicted habitat types used by goshawks as inferred from the above process for each state. Since I relied on individual observations to include whole counties in the goshawk's distribution maps, winter and breeding ranges may be overestimated. Also, forest types may not represent the vegetation at a particular point of observation and consist of coarse-scale analysis only. Finally, these observations are opportunistic and are not the result of scientifically-designed surveys conducted throughout the three states. Therefore, these findings may represent a sample of goshawk habitat that is biased based on the behavior of the observers and not the bird.

*Kansas:* Forest types in counties in which sighting of individuals occurred during both the winter and breeding seasons include: oak-hickory, elm-ash locust, and elm-ash-cottonwood (**Table 6**). Most winter sightings are predicted to occur in elm-ash locust forest type, followed by oak-hickory and elm-ash-cottonwood. The same pattern was observed with potential breeding sightings, most of which consist of elm-ash locust forest type.

*Nebraska:* Forest types of counties in which the goshawk was observed during the winter include: elm-ash locust, elm-ash-cottonwood, eastern red cedar, ponderosa pine (*Pinus ponderosa*), and oak-hickory (**Table 7**). The distribution of these forest types can be described as ponderosa pine forest type to the west, oak-hickory to the east, and a mix of elm-ash-cottonwood and elm-ash locust forest types at intermediate longitudes. It is hard to determine which forest type was associated with most of the winter sightings because several sightings occurred in counties which contain more than one dominant forest type.

**Table 6.** Associated species[1] of each forest type in which northern goshawk sightings occurred in Kansas (based on Leatherberry et al. 1999).

| Forest type | Sub-type | Associated species |
|---|---|---|
| Elm-ash-cottonwood | Cottonwood | Cottonwood (*Populus deltoides*), willow (*Salix* spp.), elm (*Ulmus* spp.), ash (*Fraxinus* spp.), soft maple (*Acer* spp.), hackberry (*Celtis occidentalis),* and black walnut (*Juglans nigra*). |
| | Elm-ash-cottonwood | Ash, hackberry, cottonwood, soft maple, elm, sycamore (*Platanus occidentalis*), black walnut, bur oak (*Quercus macrocarpa*) and willow. |
| | Willow | Black willow (*S. nigra*), cottonwood, eastern red cedar (*Juniperus virginiana*), select white oaks (*Quercus* spp.), and hickories (*Carya* spp.). |
| Elm-ash locust | Elm-ash locust | Elm, white and green ash (*F. americana* and *pennsylvanica*), locust (*Robinia* spp. and *Gleditsia* spp.), cottonwood, hackberry, select white and red oaks (*Quercus* spp.), black walnut, soft maple, sycamore, willow, hickories. |
| Oak-hickory | Red oak-white oak-hickory | Red oak, white oak (*Q. alba*), hickories, black walnut, ash, hackberry, and elm. |
| | Bur oak | Bur oak, hickory, hackberry, ash, and to a lesser degree, black walnut, and other white oaks. |
| | Post-blackjack oak | Post oak (*Q. stellata*), blackjack oak (*Q. marilandica*), select white and red oaks, and, to a lesser degree, hackberry. |

[1]Based on net volume of growing stock and all live biomass by species group from the 1994 inventory of Kansas forests (Leatherberry et al. 1999).

**Table 7.** Associated species[1] of each forest type in which northern goshawk sightings occurred in Nebraska (based on Schmidt and Wardle 1998).

| Forest type | Sub-type | Associated species |
|---|---|---|
| Eastern red cedar | Eastern red cedar | Eastern red cedar (*Juniperus virginiana*), cottonwood (*Populus deltoides*) and elm (*Ulmus* spp.). |
| | Eastern red cedar-hardwood | Eastern red cedar, cottonwood, elm, bur oak (*Quercus macrocarpa*), green ash (*Fraxinus pennsylvanica*), hackberry (*Celtis laevigata*), and black walnut (*Juglans nigra*). |
| Elm-ash-cottonwood | Cottonwood | Cottonwood, silver maple (*Acer saccharinum*), boxelder (*Acer negundo*), eastern red cedar, mulberry (*Morus* spp.), and green ash. |
| | Elm-ash-cottonwood | Elm, green ash, cottonwood, and silver maple, hackberry, boxelder, and black willow (*Salix nigra*). |
| | Willow | Black willow, cottonwood and boxelder. |
| Elm-ash locust | Elm-ash locust | Elm, green ash, honeylocust (*Gleditsia triacanthos*), black locust (*Robinia pseudoacacia*), hackberry, bur oak, eastern red cedar, black walnut and paper birch (*Betula papyrifera*). |
| Oak-hickory | Bur oak | Bur oak, eastern red cedar, hackberry, and green ash. |
| | Oak-hickory | Northern red oak (*Quercus rubra*), bur oak, chinkapin oak (*Q. muehlenbergii*), black oak (*Q. velutina*), hickories (*Carya* spp.), hackberry, elm, green ash, cottonwood, and basswood (*Tilia americana*). |
| Ponderosa pine | Ponderosa pine | Ponderosa pine (*Pinus ponderosa*). |

[1]Based on net volume of growing stock and all live biomass by species group from the 1994 inventory of Nebraska forests (Schmidt and Wardle 1998).

*South Dakota:* There are only two dominant forest types in the South Dakota counties that contained goshawk sightings (**Table 8**). The western third of the state consists mainly of ponderosa pine while the remaining two thirds is the elm-ash locust forest type (Leatherberry et al. 2000). Overall most sightings are in elm-ash locust habitat, however all confirmed breeding locations are in the ponderosa pine forest type. This pattern is supported by the goshawk species account in Peterson (1995), which reports most breeding habitat occurring in the "Upland Woodland (Coniferous)" category. According to Peterson (1995), this habitat type consists of eastern red cedar (*Juniperus virginiana*), Rocky Mountain juniper (*J. scopulorum*) and ponderosa pine. Peterson also describes most known (12 out of 16) nest sites as occurring in "Natural, non-Manmade" habitats.

*Discontinuities in distribution:* As noted in the North American distribution section, goshawks are distributed across North America and throughout forested areas of the western U.S. They nest in a variety of forest types, including boreal, deciduous and western coniferous forests. However, goshawks are not uniformly distributed throughout areas with large, contiguous areas of montane forests. It is likely that discontinuities occur in forested areas where prey abundance is low or the vegetative structure of the forest precludes access to prey. For example, goshawk nests are found throughout forested areas in the Pacific Northwest. However, they were only first found breeding in the Coast Ranges of Oregon in 1995 despite extensive surveys in what is apparently suitable habitat with abundant prey (DeStefano and McCloskey 1997). DeStefano and McCloskey (1997) suggest they are rare

**Table 8.** Associated species[1] of each forest type in which northern goshawk sightings occurred in South Dakota (based on Leatherberry et al. 2000).

| Forest type | Sub-type | Associated species |
|---|---|---|
| Elm-ash locust | Elm-ash locust | Elm (*Ulmus* spp.), white and green ash (*Fraxinus americana* and *Fraxinus pennsylvanica*), and honey locust (*Gleditsia triacanthos*), cottonwood (*Populus deltoides*), bur oak (*Quercus macrocarpa*), ponderosa pine (*Pinus ponderosa*), hackberry (*Celtis occidentalis*), basswood (*Tilia americana*), soft maple (*Acer* spp.), and to a lesser degree, eastern red cedar (*Juniperus virginiana*) and willow (*Salix* spp.). |
| Ponderosa pine | Ponderosa pine | Ponderosa pine, bur oak, white spruce (*Picea glauca*), quaking aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), and to a lesser degree, elm, ash (*Fraxinus* spp.), and cottonwood.[1] |

[1]Based on net volume of growing stock and all live biomass by species group from the 1996 inventory of South Dakota forests (Leatherberry et al. 2000).

in the Coast Ranges because of the vegetative structure and its influence on prey availability. Goshawks tend to hunt in the ground-shrub and shrub-canopy forest zones (Reynolds and Meslow 1984). A dense shrub layer is characteristic of most forests in the Coast Ranges. Although prey are abundant in this shrub layer, the dense understory conditions make the larger, ground-dwelling species (e.g., snowshoe hare (*Lepus americanus*), brush rabbits (*Sylvilagus bachmani*)) difficult to capture. Goshawks hunt many avian species which do not occur in the dense understory, but correlative evidence of prey use and demographics suggest that goshawk productivity and nest densities are lower in areas where mammal prey are sparse (Lewis 2001). If DeStefano and McCloskey's hypothesis is correct, other forest communities with extensive dense herbaceous and shrub understory would not support goshawks. This could result in discontinuities throughout the range of the goshawk.

Discontinuities in the goshawk range would also occur in areas where suitable habitat is distributed as discontinuous habitat "islands" such as the ponderosa pine forests in western Nebraska. However, goshawks are highly vagile and inter-patch distances that lead to isolation are unknown.

Band return data from Region 9 suggest that populations in Michigan, Wisconsin, Minnesota, and Ontario are not closed (Rosenfield et al. 1996, Dick and Plumpton 1998).

### Population trends

Unfortunately, there are no long-term indices of trends or estimates of goshawk breeding population size derived from standardized, widespread surveys in North America (Braun et al. 1996, Kennedy 1997). In addition, there is not sufficient information available to make a status determination for the entire breeding range contained in Region 2 or for any state within the region.

Breeding Bird Survey (BBS) and Christmas Bird Count (CBC) data are potential sources of information for estimating goshawk population trend at the scale of Region 2. BBS data are inadequate to estimate population trend for goshawks both because the number of routes on which goshawks are detected (e.g., 25 during 1997 – 2001) and the encounter rate of goshawks on these routes are too low (e.g., from 1997 – 2001 no goshawks were observed in Kansas and Nebraska, and an average of 2.6, 2.8, and 1.4 sightings/year were observed across all routes in Colorado, Wyoming and South Dakota, respectively). CBC data are also inadequate to estimate goshawk population trend because of low encounter rates. BBS and CBC methods also have many of the same methodological limitations as migration counts (discussed below). In summary, BBS and CBC data and methods are inadequate to provide reliable estimates of goshawk population trends. No other data exist that could be used to directly evaluate population trend in goshawks in Region 2 or the western U.S.

There have been three European studies that have monitored population trends and one review of regional data in Fennoscandia. Thissen et al. (1982) did a coarse-grain analysis of trends in the number of breeding pairs in the Netherlands for 1950 – 1981. Based on a review of the literature for the Netherlands and their own data, they concluded that Dutch goshawk populations have increased considerably during the 20$^{th}$ century (180-200 pairs in 1955 to > 400 pairs in 1981). They also hypothesized that the steady upward trend from 1900 was interrupted by a population crash during the sixties, presumably caused by pesticide contamination. After the pesticides were banned population growth continued. They further speculated that the major factors contributing to this increase are: 1) the extension of suitable habitat by reforestation; 2) the increase of food abundance (wood pigeon and domestic pigeon); and 3) declines in persecution by humans.

Kenward et al. (1999) estimated the finite rate of population change ($\lambda$) for a population of goshawks in Sweden. They estimated age-specific survival and productivity based on both radio-tagged birds and banded birds and used these estimates in a deterministic, staggered entry population model. Their demographic estimates are based on the largest sample size reported for a goshawk and one of the largest ever reported for a diurnal raptor (318 radio-tagged goshawks, 446 banded birds and 39 nest territories; data collected for 8 years from 1980-1987). Lambda ($\lambda$) was estimated to be 1.0 for males and 0.98 for females, which would be a 2% per annum decline for females. However, if the demographic estimates were modified to reflect the estimated range of variation in these values, (e.g., 8% SE of female survival rate estimates and productivity), $\lambda = 1$ for females as well. Because Kenward et al. (1999) did not run a stochastic population model, the effects of demographic variance on the precision of $\lambda$ is not known; but based on their limited sensitivity analyses, $\lambda$ probably does not differ from 1.

Krüger and Lindström (2001) monitored occupancy and productivity of all known nests in two 125-km$^2$ study areas in Germany. They assumed an annual census of all pairs in each study area. The number of breeding pairs fluctuated between 6 and 18 during the 25 years of study (1975-1999). Highest densities in the study area were found at the end of the 1970's, after which the sample of nests decreased sharply during the 1980's. During the last decade, the number of nests returned, albeit with fluctuations, to the level at the study onset.

Widén (1997) summarized the results of several independent studies in Fennoscandia and concluded that goshawk populations in this region declined by 50-60% from the 1950s to the 1980s. He attributes these declines to a change in forest management practices, which has changed the forest landscape, i.e., forests are more fragmented and proportion of old-growth forest has decreased. He does not summarize data from the 1990s so the current trends are unknown but he does indicate that stable populations have been reported in Finland after 1982 (Finland National Monitoring program) and a slight increase has been reported in one area in Norway. Widén's conclusions are in conflict with those of Kenward et al. (1999 – summarized above) who analyzed demographic data for one study area in Sweden during the 1980's and did not report a decline. Widén's paper summarizes existing data, and without scrutinizing those data sets, it is difficult to determine the reason for these equivocal results.

In a review of available information on goshawk populations in the U.S., Kennedy (1997) suggested that range contraction and rate of population decline, rather than population abundance or geographic range size at one point in time, may be seen as potential evidence of a species whose populations are declining. Evidence from some studies suggests that goshawk populations and reproduction may be declining in the southwest and elsewhere in the western U.S. (Herron et al. 1985 *in* USFWS 1998b, Bloom et al. 1986, Crocker-Bedford 1990, Zinn and Tibbitts 1990). However, Kennedy (1997, 1998) indicated that current sampling techniques might be insufficient to detect population trends. Kennedy (1997, 1998) concluded there is no strong evidence to indicate that goshawk populations are declining, increasing, or stationary. The difficulty in accurately measuring goshawk population trends are due to multiple factors: 1) goshawks are secretive in nature and difficult to survey, 2) many studies have small sample sizes and are temporally and spatially limited in scope, 3) potential biases exist in nest detection methods used in some studies, and 4) research methods, data analyses and interpretation are not consistent among studies, making comparisons across studies difficult. The development of a reliable population model is further complicated by the spatial and temporal variation in goshawk populations (Kennedy 1997, McClaren et al. 2002).

In response to Kennedy (1997), Crocker-Bedford (1998) stated that the rate of population change for goshawk populations in the U.S. may be impossible to calculate because the species is sparsely distributed, measurements of population parameters vary with prey cycles and weather, and immigration, emigration, and survival are difficult to estimate. Crocker-Bedford (1998) suggested that instead of trying to demonstrate a decline in goshawk populations, habitat relationships of goshawks should be examined to evaluate the amount of habitat destruction or modification that has or is occurring. Kennedy (1998) responded that habitat monitoring should augment demographic studies, not replace them, and suggested that once goshawk habitat is well-defined and demographic data are available from several study areas, a model (or models) that predicts the relationship between nesting and winter habitat and population trends and/or performance could be developed.

At Hawk Ridge in Duluth, Minnesota, more goshawks are banded than anywhere else in North

America (Palmer 1988). Data from Hawk Ridge indicate that 1972 and 1982 were years of heavy goshawk migration through Duluth (Evans 1983), and annual totals for the peak migration in the early 1990s (>2,200) were not as great as those of 1982 (5,819) or 1972 (>5,100; Evans 1981). Do these migration count data suggest anything about goshawk population trends? Smallwood (1998) and others have suggested that goshawk abundance should be evaluated based on changes in migratory counts. The utility of migration counts for monitoring population trends has been much debated (see Bildstein 1998 for a detailed discussion of the strengths and weaknesses of migration counts as an index of population size). To track population change, a constant proportion of the index (e.g., numbers of goshawk seen per day) to the true population size must be maintained. If this does not occur, then the proportion must be estimated. These validation studies have not been conducted on the goshawk for a local area or rangewide, so the trends in the current migration count data are difficult to interpret (Kennedy 1998).

Trends in migration counts could reflect distributional changes or changes in residency patterns rather than changes in population size. For example, recent analyses of CBC data suggest that numbers of the closely related sharp-shinned hawk are increasing. Several authors have suggested that more sharp-shinned hawks are overwintering in North America because of warmer winter climates and/or the abundance of bird feeders which provide a stable overwinter food source (see review in Bildstein 1998). This could be the reason that counts of sharp-shinned hawks at northern migration stations have been lower in recent years. Since goshawk migrations are characterized by irruptive invasions, migration counts of this species are more likely to reflect changes in residency patterns than changes in abundance (Bednarz et al. 1990, Titus and Fuller 1990).

Recently Hoffman et al. (2002) analyzed goshawk band encounter locations accumulated between 1980 and 2001, banded or recaptured at 4 western migration stations. Their results (although limited by sample size) suggest that migration counts of goshawks generally reflect relatively localized movements (i.e., 400 – 500 km or less). They hypothesize counts of hatching-year birds (except in invasion years) may therefore serve as an indicator of regional productivity. This hypothesis is intriguing and requires further testing. If it is supportable, Region 2 might be able to track regional productivity with counts of hatching-year birds at regional migration stations.

As mentioned in the Partners in flight section, PIF suggests that breeding populations of the goshawk in the central Rocky Mountains physiographic area (**Figure 2**) may be declining. The basis for this hypothesis is unclear.

## Activity patterns

### *Circadian, seasonal, circannual*

**Circadian patterns:** We assume goshawks move little at night similar to other diurnal species, but no one has followed radio-tagged birds at night. The only diel pattern recorded for goshawks is vocalizations. Penteriani (1999, 2001) studied the annual and diel cycles of a resident population of goshawks in France by recording vocalizations at active nest sites year-round. In his study, most goshawk vocalizations occurred during courtship. During this time vocalizations were most frequent and intense within one hour before sunrise and three hours after sunrise and the first call was always uttered before sunrise. At this time, the male (who is roosting in the nest stand) awakens vocalizing to the female and copulation regularly occurs at this time (Møller 1987, Squires and Reynolds 1997, Dewey et al. in press). Dewey et al. (in press) confirmed this pattern in a population nesting in Utah. Penteriani (2001) also found resident birds in France vocalized in the nest stand throughout the year but non-courtship vocalizations occurred throughout the day and the duration was shorter as compared to courtship.

**Seasonal and circannual patterns:** The birds have an annual cycle typical of many temperate raptors that are partial migrants. The breeding season begins from mid-February through early April and lasts until the young are independent in early August to early September. The non-breeding season occurs from September to February.

Regionally there are no data on circadian, seasonal or circannual patterns in goshawks.

*Broad-scale movement patterns*

Movements of birds beyond home range boundaries include migration, natal dispersal, and breeding dispersal. *Migration* is seasonal movement between breeding and non-breeding home ranges. *Natal dispersal* is defined as movement between a bird's natal area and its first breeding area, whereas *breeding dispersal* is defined as movements by adults between years among breeding areas (Greenwood 1980, Greenwood and Harvey 1982). Migration and dispersal are an important component of population dynamics, yet are also the least studied components for bird populations (Lebreton and Clobert 1991, Newton 1998).

**Migration/Irruption:** The existence and extent of migratory behavior is geographically and temporally variable, and may be closely tied to food availability (USFWS 1998b). The limited information on migration patterns indicates the goshawk is a partial migrant (Squires and Reynolds 1997). The most convincing evidence comes from a recent study by Sonsthagen (2002) who fitted satellite transmitters (PTTs) to 34 female goshawks breeding throughout the state of Utah. Her results confirm that in Utah goshawks were partial migrants during 2000 and 2001 (Sonsthagen 2002). Her habitat analyses of the PTT locations indicates that this sample of birds moved throughout the state of Utah and may or may not use existing forest corridors when they leave their nesting territories. The 34 female goshawks exhibited a variety of movement patterns. However, her data support previously reported patterns based on band returns (Reynolds et al. 1994, Hoffman et al. 2002) and radio telemetry (Squires and Ruggerio 1995, Stephens 2001) that goshawk migrations involve short-distance movements (< 500 km). Of the 34 birds fitted with PTTs, 19 wintered near their breeding area and 15 were migrants. The migrants moved 49 – 613 km to wintering areas and only 2 birds moved > 500 km. Band return data from the European subspecies suggest short distance movements or wandering during the non-breeding season occurs for birds that reside in southern latitudes (Buhler et al. 1987) and longer-distance migrations are more common for populations from northern latitudes (Hoglund 1964).

Goshawks in northern areas of their range are known as irruptive or irregular migrants. Irruptive goshawk migrations are believed to be a response to rapid decreases in prey populations because more migrants are reported in years of low food abundance (Mueller and Berger 1968 in USFWS 1998a, Mueller et al. 1977; Doyle and Smith 1994). Some evidence suggests that irruptions may occur at approximately 10-year intervals and coincide with declines in indices of snowshoe hare and ruffed grouse (*Bonasa umbellus*) abundance in breeding areas (Mueller and Berger 1968, Mueller et al. 1977). In other areas, migration counts indicate that some populations irrupt on a 4-year cycle (Nagy 1975). As noted by Sonsthagen (2002), we do not understand the factors that influence goshawk residency patterns.

Fall migrations generally commence after young disperse from natal areas (Palmer 1988) and occur between mid-September and mid-December. Heintzelman (1976 in Bosakowski 1999) shows that the fall migration season for goshawks extends from mid-September through November at Hawk Mountain, Pennsylvania. In New Jersey, the peak fall migration occurs mid to late October (Bosakowski 1999). From 1970 – 1994 counts of migrant goshawks ranged from 27-347 for Hawk Mountain, 106-5,819 for Hawk Ridge, 9 to 75 for Cape May and 63-252 for Goshute Mountain. These numbers are difficult to interpret because they are a function of number of observers and observer skill at identification. Spring migration is far less pronounced and poorly understood (Squires and Reynolds 1997).

Young typically migrate first (Palmer 1988) and adult males and females migrate simultaneously during irruption years (Mueller and Berger 1968, Mueller et al. 1977, Nagy 1975). However, migration of young and adults does overlap temporally, and irruptions may consist mostly of adult-plumaged hawks, because in years of low prey, few young may have been produced (Palmer 1988). Periodic invasions of goshawks have been observed along the western shore of Lake Michigan from 1950-74 (Mueller et al. 1977). The invasions were correlated with 10-year population declines in ruffed grouse and snowshoe hare. The correlation suggests that this population of goshawks migrates when prey becomes scarce.

In 1992, in south-central Wyoming (the only data on this topic from Region 2), four radio-tagged goshawks exhibited short distance migration (range = 65–185 km) beginning in mid-September and returning to nest sites between March 23 and April 12 1993 (Squires and Ruggiero 1995).

**Dispersal:** Information on dispersal is important for investigating issues of population isolation and demography. Dispersal and mortality may be more important than reproduction in governing population dynamics, but because they occur mainly outside of the nesting period, these factors are difficult to measure (Braun et al. 1996). More information on dispersal for North American and Region 2 populations would be helpful in reaching a better understanding of population dynamics.

*Natal dispersal:* Natal dispersal is the process by which individuals move from their natal area to where they reproduce or would have reproduced had they survived and mated (Greenwood 1980; Johnson and Gaines 1990; Stenseth and Lidicker 1992). Because natal dispersal involves a complex series of movements (Walls and Kenward 1995, 1998), the final natal dispersal distance is a function of the cumulative history of movements during the dispersal process (Dufty and Belthoff 2001; Wiens 2001). Successful dispersal is critical to the genetic and demographic viability of populations (USFWS 1998b). Little is known about the habitats used by goshawks during dispersal, or their dispersal directions and distances. The available information comes from recapture of marked birds, band returns, radio-telemetry, and satellite-telemetry.

Two records of band recoveries have been reported for the southwestern U.S., occurring in the year of banding at distances of 160 km (P. L. Kennedy unpublished data) and 176 km (Reynolds et al. 1994) from the natal nest. Distances from natal nest areas, for recoveries of juveniles radio-tagged in New Mexico, ranged from 5.5–176 km (n = 16; P. L. Kennedy and J. M. Ward, unpublished data). On the Kaibab Plateau, Reynolds et al. (2000) reported that 24 of 452 fledglings banded were recruited into the local breeding population. They reported that mean natal dispersal distance was 14.7 ± 8.2 km (SD; range = 3.4–36.3 km) and did not differ among sexes for the recruits. Five banded juveniles found dead outside of the study area demonstrated a potential for long-distance natal dispersal (mean = 181 ± 137 km; range = 52–442 km).

Kennedy and Ward (in press) provided clear experimental results that natal dispersal in their New Mexico population is regulated by food availability for at least the first 4 months post-fledging. After independence, radio-tagged control birds were never located in the natal area and by the end of September in 1992 and 1993 they had all left the study area. Treatment (provided supplemental food at the natal area) birds were never located outside of the study area for the duration of the experiment (late October in 1992 and late November in 1993). These results also support the idea that juveniles monitor their environment at a local scale to make dispersal decisions. These results are corroborated by correlative studies conducted by Byholm et al. (in press) on factors influencing natal dispersal in the European subspecies. Byholm et al. (in press) analyzed 12 years of band return data for birds hatched over a wide area in Finland and found local prey availability (as indexed by grouse census data) influenced dispersal distances; juvenile European goshawks remained nearer to the natal area when local grouse density was high than when grouse were scarce. No information on dispersal is available for Region 2.

*Breeding disperal:* Movements by adult goshawks from one breeding site to another between years (breeding dispersal) include movement between alternative nests within a breeding area, and movements of individuals from one breeding area to another. Although movements of a pair between alternative nests are not important demographically, they may confound detection and interpretation of movement by pairs or individuals to a different breeding area and these two types of movement can only be distinguished when individuals are marked (USFWS 1998b). Breeding dispersal could result from death of a mate, or may represent an attempt to acquire a better mate or breeding area (USFWS 1998b), and may be induced by low productivity (Reynolds *et al*. 1994). The factors influencing breeding dispersal may differ from those influencing natal dispersal, but the probability of remaining close to the natal area (philopatry) is positively related to survival and/or reproductive success (Byholm et al. in press, J. Blakesley unpublished data).

Reynolds *et al*. (1994) reported that in northern Arizona, three birds that moved from one breeding area to another in consecutive years all produced more young after the move. Reynolds et al. (2000) reported results of a study of 259 banded adult goshawks breeding in the same study area. Mean breeding dispersal distance for males was 2.4 ± 0.6 km (range = 1.9–3.5 km; n = 6) and for females was 5.0 ± 2.3 km (range = 2.4–9.0 km; n = 11). Both male and female mean dispersal distances were close to the nearest-neighbor distance (mean = 3.8 km, SD = 3.2, n = 97), indicating that dispersers moved to neighboring territories. In northern California, Detrich and Woodbridge (1994) reported higher rates of breeding dispersal. Over nine years, 18.2% of females (n = 22) and 23.1% of males (n = 13) were found breeding in more than one breeding area. Dispersal distances for females averaged 9.8 km (range = 5.5–12.9 km) and for males averaged 6.5 km (range = 4.2–10.3 km). Similar to natal dispersal, detection of maximum breeding dispersal distances is likely constrained by size of study areas and resighting technique (Koenig et al. 1996, USFWS 1998b). No estimates of breeding dispersal rates or distances are available for Region 2.

### Habitat

Prior to describing goshawk habitat associations I will define terms I will be using. The terminology I use is based on Hall et al. (1997) and Morrison (2001).

**Goshawk habitat –** the resources and conditions present in an area that produces occupancy by goshawks. This is a synonym for the niche of the goshawk based on the Grinnellian concept of the niche.

**Goshawk habitat type –** type of vegetation association in an area occupied by goshawks.

**Goshawk habitat use –** the way in which a goshawk uses a collection of physical and biological components (i.e., resources) in a habitat within an explicitly defined area in a specific period of time.

**Goshawk habitat abundance –** the absolute amount of habitat within an explicitly defined area in a specific period of time.

**Goshawk habitat availability –** the amount of habitat that is exploitable by a goshawk within an explicitly defined area in a specific period of time.

**Goshawk habitat selection –** this is a hierarchical process involving a presumed series of innate and learned behavioral decisions made by goshawks about what habitat it would use at different scales of the environment.

**Goshawk habitat preference –** this is the consequence of the goshawk's habitat selection process, resulting in disproportional use of some resources over others.

**Goshawk habitat quality –** the ability of the environment to provide conditions appropriate for individual goshawks and goshawk population persistence.

**Goshawk landscape –** a mosaic of habitat patches across which goshawks move, settle, reproduce and die. The landscape containing a goshawk population can, in principle, be mapped as a mosaic of suitable and unsuitable patches. Each map must be done at a scale appropriate to the goshawk (Meffe et al. 1997).

Most of the habitat information on the goshawk is focused on measuring forest characteristics. We do know that goshawk recruitment is regulated by an interaction of food availability and predation (Ward and Kennedy 1996, Dewey and Kennedy 2001). What forest characteristics best describe areas of high food availability and low predation risk? We don't know the answer to this question. What I have done to this point is quantify the goshawk's habitat types and in some areas its habitat type preferences. I will present what I know about these topics in general and within Region 2.

*Does habitat limit goshawk populations?*

Experimental evidence indicates prey availability and predation limit goshawk reproduction and recruitment. Another possible regulating mechanism in animal populations is territoriality. The Ideal Despotic Distribution (IDD), a form of the Ideal Free Distribution, predicts in territorial species, high quality territories are occupied first and as densities increase more and more of the poor quality territories are occupied (Fretwell and Lucas 1970, Pulliam and Danielson 1991). The *habitat heterogeneity hypothesis* links the IDD to density dependence: increased usage of poor territories in high densities results in a decrease in per capita reproductive success (Krüger and Lindström 2001). This is also referred to as *site-dependent population regulation* (Rodenhouse et al. 1997). In territorial species, *interference competition* (from conspecifics) could also give rise to an inverse relationship between density and population growth rate.

Krüger and Lindström (2001) analyzed a 25-year dataset (1975-1999) of a German goshawk breeding population to evaluate the site-dependent population regulation hypothesis and the interference competition hypotheses. They analyzed territory settlement patterns and breeding performance and modeled per capita growth rate using standard time-series analyses and model selection procedures. In their study area, territories that were occupied more often and earlier had a higher mean brood size, and fecundity did not increase with increasing density in the best territories. There was also a strong negative relationship between mean number of young per breeding pair and its coefficient of variation, suggesting that site-dependent population regulation was more likely regulating this population than interference competition. I agree that territory quality does seem to influence growth rate in their study area. However, we still do not understand what site factors regulate goshawk populations. I do agree their results suggest site-dependent population regulation is a more plausible hypothesis for regulating goshawk population growth rate in Germany than interference competition.

Kenward and Widén (1989) argue that European data on goshawk hunting preferences suggest food was the main factor determining habitat use by European goshawks. In Europe, goshawks nest in boreal forest areas as well as in woodlands adjacent to farmland. In the woodland-farmland areas the hawks had a strong preference for hunting within 200 m of edges (Kenward and Widén 1989). In the boreal forest areas, there was no preference for edges. In these areas they tended to hunt most often in the largest patches of mature forest. Kenward and Widén hypothesize that these radical differences in foraging habitat preferences are attributable to differences in prey availability between areas. Squirrels (*Sciurus vulgaris*) were the primary prey in the boreal forest and pheasants (*Phasianus colchicus*) were the primary prey in the woodlands.

In conclusion, there is experimental and correlative evidence that prey availability and predation limits goshawk recruitment and correlative evidence that density-dependent territoriality regulates population growth rate. No studies have been done that evaluate all possible mechanisms simultaneously and no studies on population regulation have been conducted in Region 2.

*Overview of goshawk habitat studies*

Historically labelled an old-growth indicator species by the USFS in the 1980s (Sidle and Suring 1986 in USFWS 1998b), the goshawk's preference for old or mature forests has been a topic of debate (Kennedy 1997, 1998). The status review conducted by USFWS "found that while the goshawk typically does use mature forest or larger trees for nesting habitat, it appears to be a forest generalist in terms of the types and ages of forests it will use to meet its life history requirements. Goshawks can use small patches of mature habitat to meet their nesting requirements within a mosaic of habitats of different age classes" (USFWS 1998b).

The status review was written prior to the most recent USFWS decision not to list the goshawk as threatened and points to potential biases that need to be addressed in goshawk habitat studies (USFWS 1998b). The bias common in many goshawk habitat studies pertains to methods used for detecting nesting goshawks. Because goshawks are generally secretive and difficult to survey, nests used in habitat studies are often located in ways that may favor older-aged forests, such as detection during preparation of timber sales. In other studies, researchers have chosen areas in which to survey or search for nests based on preconceived notions of what constitutes goshawk habitat. This method tends to favor mature and old-growth forests (Daw et al. 1998, Rosenfield et al. 1998).

Nest site habitat for the goshawk has been described throughout much of its range in North America and Europe (Shuster 1980, Reynolds et al. 1982, Moore and Henny 1983, Hayward and Escano 1989, Siders and Kennedy 1996, Squires and Reynolds 1997, Rosenfield et al. 1998). Several studies in the U.S. and Europe have compared habitat characteristics at nest areas to those available habitats within home ranges or landscapes and can be used to draw some conclusions about goshawk nesting habitat preferences (Speiser and Bosakowski 1987, Kennedy 1988, Bosakowski and Speiser 1994, Hargis et al. 1994, Squires and Ruggiero 1996, Penteriani and Faivre 1997, Selås 1997, Daw and DeStefano 2001). A few breeding foraging habitat preference studies (Widén 1989, Bright-Smith and Mannan 1994, Beier and Drennan 1997, Lapinski 2000, Boal et al. 2002) and one post-fledging habitat preference study have been conducted (Daw and DeStefano 2001). Winter habitat studies have been conducted primarily in Europe (e.g., Kenward et al. 1981, Tornberg and Colpaert 2001) but two unpublished studies (Alaska – Iverson et al. 1996, Utah – Stephens 2001) and one published study (Drennan and Beier in press) have been conducted in North America. The effects of changes in forest landscapes on habitat selection by goshawks in any season are unknown and additional research is needed at larger spatial scales (USFWS 1998b).

Seven habitat studies have been conducted in Region 2 and six of them focused on nest site habitat type use and preferences. Only four of the studies have been published (White et al. 1965, Shuster 1980, Squires and Ruggiero 1995, Squires and Ruggiero 1996). Three studies were conducted in Colorado (White et al. 1965, Shuster 1980, Joy 1990), two studies in Wyoming (Squires and Ruggiero 1995, 1996) and two in South Dakota (Bartelt 1977, Erickson 1987). The inference space of all studies, except for the two Wyoming studies, is restricted to their sample of nests (or birds – winter habitat) because none of the goshawk nests were located using unbiased sampling techniques.

Squires and Ruggiero (1996) conducted an extensive habitat preference analysis of goshawk nesting habitat in south central Wyoming. They located approximately half of their 39 goshawk territories using unbiased surveys. The remaining nests were located from a variety of sources. Although they did not test for habitat biases as a result of search technique, their inference probably extends to their study population. The results of these studies will be described in detail in the following sections.

### *Breeding season habitat*

Breeding season habitat includes nesting, post-fledging areas (PFA) and foraging habitat. The approximate spatial distribution of these components of breeding season habitat is portrayed graphically in **Figure 12**.

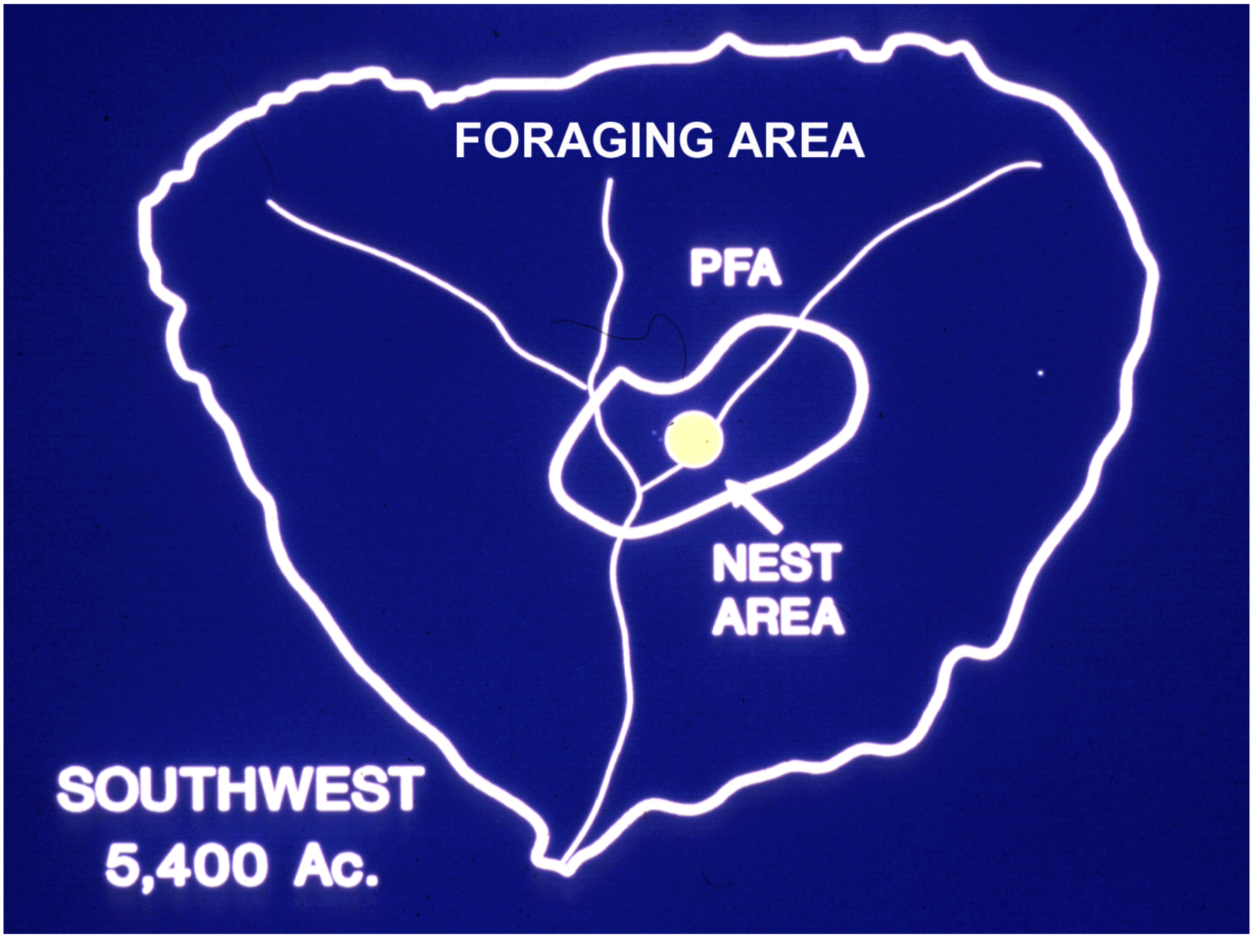


**Figure 12.** Conceptual diagram of the northern goshawk home range during the breeding season. The three components are the nest area, post-fledging area (PFA) and foraging area. In the southwestern US, total area of the home range is estimated at 2,185 ha.

**Nest area:** The area immediately surrounding the nest tree, referred to as the nest site or nest area (Steenhof 1987), often contains alternative nests and may be reused in consecutive years (Palmer 1988). The nest area includes the forest stand containing the nest tree(s) although definitions beyond the nest stand have varied by location and study (Dick and Plumpton 1998). Reynolds et al. (1992) defined a nest area as approximately 12 ha in size that is the center of movements and behaviors associated with breeding from courtship through fledging. Daw et al. (1998) summarized data from goshawk habitat studies in the West and indicated an important pattern is emerging from these studies. They concluded goshawks tend to select nest stands that are characterized by relatively large trees and relatively high canopy closure (>50–60%), regardless of region or forest type.

*Nest tree:* Goshawks nest in both deciduous and coniferous trees (Palmer 1988, Squires and Reynolds 1997) and appear to choose nest trees based on size and structure more than species of tree (USFWS 1998b). Goshawks often nest in one of the largest trees in the stand (Reynolds et al. 1982, Saunders 1982, Erickson 1987, Hargis et al. 1994, Squires and Ruggiero 1996), with height and diameter of nest trees varying geographically and with forest type. In Wyoming (Squires and Ruggiero 1996) and California (Saunders 1982), goshawks chose nest trees that had larger diameters than other trees in the nest stand. However, in some eastern forests only 4 of 32 nests were built in the largest tree of the nest area (Speiser and Bosakowski 1989).

As in other regions of North America, goshawk nests in Region 2 are found in a variety of tree species. **Table 16** contains a list of goshawk nest trees reported from studies conducted in Region 2. They have been reported nesting in 5 tree species: Fremont cottonwood (*Populus fremontii*), Quaking aspen (*Populus tremuloides*), Ponderosa pine (*Pinus ponderosa*), Lodgepole pine and subalpine fir (*Abies lasiocarpa*). Nest tree dbh ranges from 20-50 cm and mean tree height ranges from 18 – 23 m.

*Nest structure and location in tree:* Goshawks typically construct their nests just below the forest canopy in the upper portion of the lower one-third of the nest tree (Shuster 1980, Reynolds et al. 1982, Moore and Henny 1983, Speiser and Bosakowski 1987). Heights of goshawk nests are significantly correlated with nest tree heights (Kennedy 1988, Speiser and Bosakowski 1989), which vary with tree species and regional differences in tree heights (USFWS 1998b). The average height of North American nests was reported by Apfelbaum and Seelbach (1983) as 11.8 m (range = 6.1–25.7 m). Shuster (1980) reported for 20 nests in Colorado that nest height varied directly with tree height in aspen, while in pine the correlation was not as strong.

Peck and James (1983) stated that nests in Ontario are bulky structures of twigs and branches reaching up to 90 cm in height, with outside diameters (n = 6) ranging from 43–106.5 cm and inside diameters (n = 2) of 23 and 53.5 cm. These nests had shallow cups and were lined with various items, such as fresh sprigs of hemlock, pine, or cedar, dried and fresh leaves, grasses, mosses, feathers, clay, and bark chips (Peck and James 1983). The nests (n = 29) were positioned in forks of branches at the trunk or in main crotches at heights ranging from 7.5–23 m with most (n = 15) between 9–12 m. In Oregon, 12 nests averaged 94 cm $\pm$ 18.5 in length, 66 cm $\pm$ 20.3 in width; depression inside each nest averaged 24 cm $\pm$ 7.0 in length, 21 cm $\pm$ 4.0 in width, and 8 cm $\pm$ 7.6 in depth (Bull and Hohmann 1994). In Alaska, nests averaged 80 cm in length and 50 cm in width (McGowan 1975). In New York 12 nests averaged 90-120 cm in diameter and 60 cm in height (Allen 1978).

Although canopy closure in the nest area is often cited as an important habitat feature (Squires and Reynolds 1997), the nest tree itself may be dead and offer little canopy closure (Dick and Plumpton 1998). Successful nests have been recorded in dead white pines in Minnesota (Martell and Dick 1996) and Porter and Wilcox (1941) reported a successful nest in a dead aspen tree in Michigan. Snag nesting is a common practice for goshawks nesting in the Ashley National Forest in Utah (S. R. Dewey and P. L. Kennedy unpublished data).

*Alternative nests/alternative nest areas:* Typical goshawk breeding areas contain several alternative nests that are used over several years (Reynolds and

Wight 1978, Speiser and Bosakowski 1987, Reynolds et al. 1994, Woodbridge and Detrich 1994, Reynolds and Joy 1998). Although goshawks may use the same nest in consecutive years, goshawk breeding areas often contain 1–5 or more alternative nests that are used by pairs over several years and are usually located within 0.4 km of each other (Reynolds and Wight 1978, Speiser and Bosakowski 1987, Reynolds et al. 1994, Woodbridge and Detrich 1994, Reynolds and Joy 1998, Dewey et al. in press). They may be found clumped in 2–3 adjacent stands or distributed over a much larger area (Woodbridge and Detrich 1994). Difficulties in locating alternative nests and nest areas and differences in survey methods and nest search protocol can make fidelity to breeding areas and other productivity parameters difficult to estimate and may confound comparisons of occupancy and productivity data (Dick and Plumpton 1998).

In northern California, the mean number of nests used by goshawk pairs was 2.6 and only 44% of nesting attempts were in nests used the previous year. The mean spacing between alternative nests was 273 m, with a range of 30–2,066 m (Woodbridge and Detrich 1994). In Arizona, 59 breeding areas that contained alternative nests had a mean spacing between them of 489 m, and a range of 21–3,410 m; median = 285 m, Reynolds and Joy 1998). Average distance between alternative nests in the Uinta Mountains in Utah was 352 m (Dewey et al. in press). No regional data are available on alternative nests.

*Dominant habitat types:* Forest types associated with goshawk nest areas vary geographically (USFWS 1998b). In New York, sugar maple, yellow birch, beech, and hemlock were dominant in most nest areas (Allen 1978), whereas forest types in western nest areas include all montane forest types (White et al. 1965, Bartelt 1977, Reynolds et al. 1982, Saunders 1982, Hall 1984, Allison 1996, Squires and Ruggiero 1996, Desimone 1997). In the interior of Alaska, stands of paper birch were used more commonly than any other forest type and paper birch was the dominant tree species in other forest types with goshawk nests (McGowan 1975a). In southeast Alaska, however, there was significantly more hemlock (81%) at goshawk nest areas than randomly available (75%; Iverson et al. 1996).

Dominant habitat types at nest sites in Region 2 have been reported in two studies, Bartelt (1977) and Squires and Ruggiero (1996). In the Black Hills of South Dakota, Bartelt found all nest sites in ponderosa pine, and in Wyoming Squires and Ruggiero found all nest sites in lodgepole pine. Based on USFS biologists' records (G. Hayward, USFS Region 2, personal communication) other forest types are used by goshawks in Region 2 but habitat studies have not been conducted in these types.

*Forest structure and landscape features at nests:* Although the goshawk is considered a habitat generalist at large spatial scales and uses a wide variety of forest types, it tends to nest in a relatively narrow range of structural conditions (Reynolds et al. 1992, Squires and Reynolds 1997). Goshawks seem to prefer mature forests with large trees, relatively closed canopies (60–90%), and open understories (Moore and Henny 1983, Speiser and Bosakowski 1987, Crocker-Bedford and Chaney 1988, Kennedy 1988, Hayward and Escano 1989, Reynolds et al. 1992, Squires and Ruggiero 1996, Penteriani and Faivre 1997, Selås 1997, Squires and Reynolds 1997, Daw *et al*. 1998, Daw and DeStefano 2001, Finn et al. in press). Due to frequent bias in goshawk nest detection methods, however, goshawk selection of mature forests over other forest stages has been demonstrated in only a few studies (Kennedy and Andersen 1999). Squires and Reynolds (1997) state that nests are frequently found near the lower portion of moderate slopes, close to water, and often adjacent to a canopy break. Nesting in stands relatively denser than surrounding forests may reduce predation and, in combination with north slopes, may provide relatively mild and stable micro-climates (Reynolds et al. 1992).

Reynolds et al. (1982) reported goshawks in Oregon nesting in dense, mature or old-growth conifers with a mean tree density of 482 trees/ha and a range of 273–750 trees/ha. Nest areas included forests with few mature trees and dense understory trees, forests with closed mature canopies and sparse understory trees and several variations in between. Most nest areas were in old forests, with only 5% in second growth forests and 4% in mature lodgepole pine or mixed stands of mature lodgepole and ponderosa pine. The lodgepole nest areas had relatively open, single-layered canopies (166 trees/ha, 38% canopy closure). In their Oregon study area, Daw et al. (1998) found nests that were located systematically were found in areas with an average of 16.4 large trees (>53 cm dbh)/ha and a mean canopy closure of 72.4%. Daw and DeStefano (2001) compared goshawk nest stands to stands with random points in Oregon and found goshawks nested more frequently in stands with dense canopy and late forest structure (i.e., trees >53 cm dbh, canopy cover >50%), but rarely in stands with mid-aged forest structure. They also found nests were positively associated with small dry openings. They reported that average nest-stand size in older forests was about 100 ha (range = 3–375 ha), but emphasized that stand quality is more important than stand size.

Siders and Kennedy (1996) described the range of stand conditions used by goshawks in northern New Mexico. They reported goshawks used nest trees ranging from 25–31 m in height and 43.3–56.7 cm dbh. Canopy closure at the nest tree was 58–74% and at nest areas was 60–70%. Nest areas had 31–40 $m^2$/ha basal area, with an overall area density of 800–1,400 trees/ha and overstory trees were spaced 4.8–6.8 m apart. Nest areas were composed of 2.8–8.0% mature, 2.1–11.1% large, 5.2–32.8% pole, and 16.8–85.6% sapling trees. Tree densities by age class were 460–970 sapling trees/ha, 130-370 pole trees/ha, 55–115 large trees/ha, and 53–90 mature trees/ha.

In northern California, canopy closure at nests ranged from 53 to 92% (Saunders 1982), and in northern Arizona, goshawks preferred nest areas that had the greatest canopy closure available, averaging 76%, which was 18% greater than in 360 reference areas (Crocker-Bedford and Chaney 1988). In eastern California, Hargis et al. (1994) reported home range locations used by goshawks were similar to nest areas, and both had greater canopy cover, greater basal area, and more trees/ha than a random sample from the study area.

Despite differences in some habitat characteristics, high canopy closure and tree basal area at nest areas were the most uniform habitat characteristic between study areas in northern Idaho and western Montana (Hayward and Escano 1989). Tree basal area ranged from 29 to 54 $m^2$/ha, with most (60%) nest stands between 39 and 46 $m^2$/ha.

Although goshawks appear to select relatively closed-canopy forests for nesting, there are exceptions and they will nest in more open forests (USFWS 1998b). Goshawks nest in tall willow communities along major drainages in arctic tundra (Swem and Adams 1992) and riparian cottonwood stands (White et al. 1965). In Oregon, Reynolds et al. (1982) reported seven nest areas had an average canopy closure of 59.8%, although three nests were located in stands of mature lodge-pole pine that were relatively open (38% canopy coverage). Also, a reported average canopy closure of 31% in nest stands in eastern California was low compared to other goshawk studies (Hargis et al. 1994).

Aspect and slope in nest areas may influence microclimate and goshawk habitat selection. In southern portions of their range, goshawk nest areas typically have northerly aspects and are located near the bottom of moderate slopes (USFWS 1998b). Studies conducted in Oregon (Reynolds et al. 1982), Idaho, and Montana (Hayward and Escano 1989) found a significant number (40–60%) of goshawk nest locations followed this pattern, with nests on slopes with northwest to northeast-facing aspects. Bosakowski and Speiser (1994) compared goshawk nest sites to random points throughout their study area in New York and New Jersey and found goshawks avoided nesting on slopes with southerly aspects relative to the abundance of these slopes. Average slopes in nest areas were 9% (range = 0 – 75%) in Oregon (Reynolds et al. 1982), 14% in northeastern Oregon (Moore and Henny 1983), and less than 50% slope in Idaho and Montana (Hayward and Escano 1989). Although goshawks nesting in New Mexico (Siders and Kennedy 1996) and Wyoming (Squires and Ruggiero 1996) did not exhibit a preference for aspect, most nests were found on moderate slopes. Goshawks nesting in northwestern California used slopes averaging 42%, which are some of the steepest slopes recorded (Hall 1984).

In contrast, most goshawks (64%) found nesting in interior Alaska were on slopes with southern aspects. In addition, they seemed to favor mid-slope locations with 16% on the upper portion of the slope, 46% on the middle portion, and 38% on the lower portion of the slope (McGowan 1975).

There are three known sources of information for forest structure and landscape features of nest areas in Region 2: Bartelt (1977), Shuster (1980) and Squires and Ruggiero (1996). These studies support the patterns reported elsewhere. In Colorado, (Shuster 1980) and South Dakota (Bartelt 1977) nest sites were located on gentle (0-40%), north and east facing slopes or benches. Nest sites in Colorado aspen and pine stands had basal areas of 99-152 and 52-88 $m^2$/ha, respectively. Most South Dakota sites were in stands with > 37 $m^2$/ha basal area (Bartelt stated that any stand with a basal area > 28$m^2$/ha is silviculturally over-stocked). The South Dakota nests were near (< 50 m) dense pole stands. Understory in the stand was sparse or absent.

Nest stands of south central Wyoming goshawks ranged from 0.4 – 13.0 ha. Slopes were more moderate (mean = 11%) than available topography but there was no preference for aspect. Tree densities at nest sites were lower than at random sites but densities of large tress were higher than at random sites. Nest stands were not old-growth in the classic sense of being multi-storied stands with large diameter trees, high canopy closure and abundant woody debris. Rather nest stands were in even-aged, single-storied, mature forests stands with high canopy closure (mean = 65%), similar to what has been documented in other regions.

Early authors suggested goshawk nests are associated with water (Bond 1942, Squires and Reynolds 1997, Shuster 1980, Reynolds et al. 1982, Hargis et al. 1994). In Region 2 (CO), Shuster (1980) found all nests in aspen stands were near running water and those nests in pine stands were from 10–450 m from water sources. Most South Dakota nests were found within 0.84 km of water although several nests were not within 1 km of a water source (Bartelt 1977). Conversely, some studies have shown that nests are not associated with water (Speiser and Bosakowski 1987, Crocker-Bedford and Chaney 1988) and the potential functional significance of water to goshawk nest sites has not been investigated.

*Forest openings:* Reports of goshawks nesting close to forest openings such as meadows, forest clearings, logging trails, dirt roads, and fallen trees are common (Gromme 1935, Reynolds et al. 1982, Hall 1984, Erickson 1987, Hayward and Escano 1989). Although the function of forest openings near nests is unclear, they may increase access to the nest or aid in locating nests (USFWS 1998b). In Region 2, there is little descriptive information on the landscape features of nest areas except for what I have presented.

**Foraging habitat:** Goshawk nesting habitat is well described at the nest tree and nest stand levels, but how goshawks use habitats away from their nests during their nesting season is poorly understood. A few studies have been conducted in North America that attempt to describe breeding season foraging habitat (Austin 1993, Bright-Smith and Mannan 1994, Beier and Drennan 1997, Good 1998, Lapinski 2000, Boal *et al*. 2002, Finn et al. 2002). These studies have defined foraging habitat in a variety of ways, which limits our ability to make cross-study comparisons. These definitions include: 1) all habitat within a home range not included in the nest area; 2) habitat at locations of goshawks obtained by radio tracking tagged birds; and 3) habitat at known kill sites located by detailed tracking of radio-tagged birds. Home range analyses estimate home range size based on locations of radio-tagged birds or assume the home range can be represented by a circular area centered on the nest.

Results from these studies suggest goshawks use all forest types, but appear to select forests with a high density of large trees, greater canopy cover and high canopy closure, high basal area and relatively open understories in which to hunt (Beier and Drennan 1997). Despite these preferences, several studies also report a tolerance for a broad range of forest structures (Kenward 1982, Widén 1989, Austin 1993, Bright-Smith and Mannan 1994, Hargis *et al*. 1994, Beier and Drennan 1997). Beier and Drennan (1997) suggested goshawks in their northern Arizona study area use all types of forest stands. It is also important to note that while some habitats may be avoided by foraging goshawks, they may actually be important in terms of prey production (Boal *et al*. 2002).

In southwestern Yukon, Canada, 33% of goshawk kills were in dense forest cover although only 18% of the area contained this cover type (Doyle and Smith 1994). Hargis et al. (1994) found goshawks foraging in forest stands with higher basal area, more canopy cover, and more trees in large diameter classes than were randomly available. Similarly, goshawks in the southern Cascades preferred the oldest, densest vegetation type available and avoided the youngest, most open vegetation (Austin 1993). They found that goshawks did not select foraging habitat based on prey abundance, but rather chose sites with higher canopy closure, greater tree density, and greater density of trees >40.6 cm dbh than on contrast plots. They also reported a mean canopy closure of 48% on used plots; aversion to canopy closures <40% and a strong preference for areas with canopy closure>80%.

Goshawks have been seen hunting in openings and along edges. Shuster (1980) observed goshawks hunting in openings and clearcuts in Colorado. In Nevada, three males foraged in open sagebrush away from trees (based on 13 visual locations) and along the edge of aspen groves to hunt Belding's ground squirrels in sagebrush (Younk and Bechard 1994). In Europe, Kenward (1982) collected detailed movement data on 4 radio-tagged goshawks. These birds spent a substantial amount of time hunting along edges and crossing openings between woodlands. These studies indicate that goshawks hunt in open and edge habitats; however, the degree to which they rely on these edges for prey is unclear.

Reynolds and Meslow (1984) assigned bird and mammal prey species in forested habitat to four height zones (ground-shrub, shrub-canopy, canopy, aerial) based on where each species spends most of its time. They found 40% of prey species in goshawk diets were zone generalists; 35% were most often in the ground/shrub layer; and the remaining prey were evenly distributed between shrub-canopy and canopy layers. Reynolds et al. (1992) indicated large-bodied prey might be more important to breeding goshawks than smaller prey. In the Reynolds and Meslow (1984) study, large-bodied mammals and avian prey were primarily associated with lower forest strata or were zone generalists. In Arizona, 62% of prey was captured from the ground/shrub zone, 25% was zone generalists, 13% was from the shrub/canopy and canopy zones, and highly aerial prey, such as swallows, were not observed in goshawk diets (Boal and Mannan 1994).

DeStefano and McCloskey (1997) reported that in the coast ranges of Oregon, goshawks are rare even though goshawk prey species are varied and abundant. Forests in this area contain high understory stem densities and dense undergrowth, which may make prey species difficult to capture. DeStefano and McCloskey (1997) suggested that if a relationship between vegetation structure and prey availability does exist, these forest conditions might limit prey availability to goshawks.

In Region 2, Good (1998) described foraging movements of 5 male goshawks breeding in south central Wyoming in 1996 and 1997. He examined four factors at each kill site: 1) prey abundance, 2) habitat characteristics, 3) landscape patterns and 4) habitat needs of prey species. Similar to Beier and Drennan's study (1997), Good found that the relative use of kill areas was more frequently correlated with habitat characteristics than prey abundance. The majority of goshawks (n = 3) in his sample returned most often to sites with more mature forests, gentler slopes (6-60%), lower ground coverage of woody plants (1-30%) and greater densities of large conifers (23-37.5 cm dbh; range = 0-11 stems/0.04 ha). Goshawk kill areas were often associated with small natural openings, as were many prey species. Good also suggested that goshawks may return to areas more often where large numbers of prey are present because two individuals in his sample regularly returned to kill sites with high prey abundance.

Based on results of goshawk foraging studies in Fennoscandia, Widén (1997) notes that goshawk hunting success depends not only prey density, but also on different habitat features that determine its ability to hunt. This may be a major factor influencing their preference for hunting in mature forest. He claims mature forest provides abundant prey and perches yet is open enough in forest structure to allow the goshawk to maneuver and attack.

**Post-fledging area (PFA) and multi-scale habitat studies:** The PFA surrounds the nest area and is defined as the area used by the family group from the time the young fledge until they are no longer dependent on the adults for food (Reynolds et al. 1992, Kennedy et al. 1994). Reynolds et al. (1992) also assumed that all alternative nests were within the PFA. During the fledgling-dependency period the activities of young are centered near their nests, but they move farther from the nest over time (Kennedy et al. 1994, Kennedy and Ward in press). PFAs may be important to fledglings by providing prey items on which to develop hunting skills, as well as cover from predators and prey. The PFA was conceptualized by Reynolds et al. (1992) and empirically supported by movement patterns of goshawk families by Kennedy et al (1994), Kenward et al. (1993a) and Kennedy and Ward (in press). However, PFA size and the functional significance of this spatial scale to goshawk management needs further evaluation. Kennedy et al. (1994) reported PFAs in New Mexico averaged 170 ha in size and suggested this area may correspond to the area defended by a goshawk pair.

Johansson et al. (1994) used elevation and vegetation models to predict potential goshawk nesting sites in the Dixie National Forest in Utah. Using a sample of 30 nest sites to develop and "test" the model, they found the model with the best predictive capability included elevation and vegetative characteristics of the nest stand plus the vegetative characteristics of the PFA as defined by Reynolds et al. (1992). They did not examine the influence of larger spatial scales on the ability to predict goshawk nest sites nor did they describe habitat within the PFA.

The first evaluation of PFA habitat was conducted by Daw and DeStefano (2001). They compared forest structure around 22 nests with forest structure around random points. Comparisons were made at 6 spatial scales from the nest stand up to a 170-ha PFA. They found that within circles of 12 ha and 24 ha plots around nests, late forest structure was more abundant than around random points. They also reported forest structure at the PFA-scale was dominated by dense-canopied forest and always contained wet openings.

Reynolds et al. (1992) hypothesized the PFA would be intermediate in heterogeneity between the nest area and home range. This concept was recently supported by a study conducted by Finn et al. (2002). They quantified habitat structure, composition, and configuration at three spatial scales (39 ha nest area; 177 ha PFA; and 1, 886 ha home range) at 30 historical nest sites on the Olympic Peninsula, Washington and described the relationship between goshawk occupancy (during 1996-1998) and these characteristics. Habitat differences between occupied and unoccupied sites were most apparent with increasing spatial scale. The relationship between goshawk occupancy and proportion of late-seral forest and stand initiation cover increased proportionately with increasing spatial scale. Habitat conditions at the nest-area scale were more similar between occupied and unoccupied sites than were habitat conditions in PFAs or home ranges. Also, goshawks occupied areas with more heterogeneity and more early stand initiation forest within their home range than within the PFA.

McGrath et al (in press) further evaluated this question of goshawk habitat at various spatial scales in one of the most intensive modeling efforts I have seen on this topic. They compared nesting habitat on 4 study areas in eastern Oregon and Washington during 1992- 1995. Eight habitat scales ranging from 1 ha to the 170 ha (PFA scale) surrounding 82 nests and 95 random sites were analyzed to describe goshawk nesting habitat at biologically relevant scales and to develop models capable of assessing the effects of forest management alternatives on habitat suitability. At the 1-ha scale, the stage of stand development, low topographic position and high stand basal area reliably discriminated between nests and random sites. At larger scales, later seral stages, high understory growth, and high canopy closure were more common around nests than random sites and these effects were prevalent up to 83 ha. They provide convincing evidence that in their study area, there is a core area around goshawk nests where the forest can be characterized by large trees with high canopy closure and this core is surrounded by a heterogeneous landscape with forest cover types that are equally abundant. Although the functional significance of this 83-ha has not been demonstrated, they speculate the habitat conditions within 500 m (approximately 80 ha) may provide the PFA-like conditions described by Reynolds et al. (1992) and Kennedy et al. (1994). This suggests that similar to home ranges, PFAs likely vary in size (i.e., 80 – 170 ha) depending on local environmental conditions (i.e., availability of vulnerable prey, predation risk).

Penteriani et al. (2001) described goshawk nests site preferences in France by using a multi-scale analysis: nest tree, nest stand (1 ha) and landscape to compare 50 goshawk nest sites with random plots. The landscape was analysed as a circular plot with a 2-km diameter centered on each of the 50 active nest trees and random points. Plot diameter was equal to the minimum nearest-neighbor distance. Avian abundance was estimated in each landscape plot as an index of prey availability. Their stepwise logistic regression showed that 4 nest stand structural variables (larger average dbh, larger crown volume, higher flight space and shorter distance to trails) and 2 landscape variables (low avian prey richness for both 100-500 g and 501-2000 g prey size classes) were significant predictors of goshawk nest sites as compared to random sites. Their results support the results of Beier and Drennan (1997) who argue that goshawks apparently select habitat based on forest structural characteristics and not prey abundance. Penteriani et al. (2001) conclude that goshawks in their study area choose nest sites based on stand structural features and then focus on the selection of the nest tree.

*Nonbreeding habitat*

The goshawk is considered a winter resident throughout its breeding range, however, some goshawks regularly winter outside their breeding areas (Squires and Reynolds 1997). In the United States, only a few studies have documented goshawk winter ecology (Doerr and Enderson 1965, Alaska Department of Fish and Game 1993, Squires and Ruggiero 1995, Stephens 2001, Drennan and Beier in press) and understanding of goshawk biology during the winter comes largely from Europe (Opdam *et al*. 1977; Kenward et al. 1981; Marcström and Kenward 1981; Widén 1985, 1987, 1989; Kostrzewa and Kostrzewa 1991, Tornberg and Colpaert 2001). The degree to which these results can be applied to goshawks in North America is unknown (USFWS 1998b).

The European studies suggest that prey abundance and not habitat per se may be an important factor affecting habitat use by goshawks during the winter, particularly at northern latitudes (Sunde 2002). However, a recent study of forest structure and prey abundance at goshawk winter kill sites by Drennan and Beier (in press) suggests that goshawks select winter foraging sites in northern Arizona based on forest structure rather than prey abundance. In their northern Arizona study area, kill sites of 13 radio-tagged adult goshawks (6 males and 7 females) had more medium-sized trees and denser canopies than nearby paired sites that lacked evidence of goshawk use. Prey abundance indices were nearly equal at used and reference plots. This pattern is consistent with their results for breeding season foraging habitat in the same study area (Beier and Drennan 1997). However, the results of both Arizona studies need to be interpreted cautiously because they use prey abundance indices that do not account for detection probabilities which has been demonstrated to be difficult to interpret by numerous authors (e.g., Buckland et al. 2001).

In the winter, goshawks have been reported to use a variety of vegetation types, such as forests, woodlands, shrub lands, and forested riparian strips in search of prey (Squires and Ruggiero 1995, Kirkley 1999, Drennan and Beier in press). In northern Arizona, adult goshawks continued to use their breeding season home ranges in ponderosa pine and most males moved into lower elevation, pinyon-juniper woodlands during the winter (Drennan and Beier in press).

Breeding goshawks radio-tagged in north-central Minnesota (Boal et al. 2002) were non-migratory and generally sedentary during the winter, and often maintained a close association with the breeding home range during the non-breeding season. However, Boal et al. (2002) noted that winter home ranges were larger than breeding season home ranges. This study was conducted from 1998–2000; the degree to which goshawks in the region remain resident on their breeding areas over time is unknown. It is likely this residency pattern will vary with cycles of dominant boreal prey such as snowshoe hares, but this is purely speculative at this time. Habitat use by these Minnesota wintering birds has not yet been analyzed.

Stephens (2001) estimated winter home ranges of 12 goshawks breeding in the Uinta Mountains in Utah. This is the largest sample size of winter birds observed in North America. He analyzed landscapes of the home range. The four core range habitat types were: 1) mixed-conifer forests at higher elevations composed primarily of lodgepole pine, subalpine fir, and/or Douglas fir (*Pseudotsuga menzeseii*), 2) woodlands composed primarily of pinyon/juniper and agricultural areas adjacent to the woodland, 3) a combination of the first two habitat types, and 4) lowland riparian areas adjacent to salt-desert scrub. The birds demonstrated a preference for habitats 1, 3 and 4. These data indicate this sample of goshawks had winter home ranges with a higher diversity of vegetation types and more patches than the rest of the study area. Stephens (2001) speculated these areas may have supported a more diverse prey base. His data also support the observations of Drennan and Beier (in press) that birds will winter in habitats not used for nesting, i.e., pinyon-juniper woodland.

Widén (1989) tracked radio-tagged goshawks (n = 23 males; 20 females) in Sweden that wintered in highly fragmented forests interspersed with clear cuts, wetlands and agricultural lands. In this study, goshawks killed more than half of their prey in large (>40 ha) patches of mature forests (70 years old) and used these areas significantly more than what was proportionately available. Young and middle-aged forests were used by goshawks in proportion to abundance. Mature forests allowed goshawks to hunt while remaining undetected by prey, but were also open enough for birds to maneuver when attacking prey (Widén 1989).

In England, Kenward (1982) tracked four goshawks that spent 50% of their time in and took 70% of their prey from the 12% of woodland contained within their home ranges. Another study conducted in agricultural areas of England (Kenward and Widén 1989) reported wintering goshawks used edge habitats for foraging. Differences in habitat use may be attributed to different prey distributions (Kenward and Widén 1989). Kenward and Widén (1989) reported that in boreal forests, goshawks prey primarily on squirrels found distributed throughout the forest, whereas in agricultural areas goshawks hunt near forest edges where prey are more abundant. Goshawk home ranges in agricultural areas were smallest where prey densities were greatest, and were largest in areas that contained the least woodland edge, suggesting that prey distribution was the factor that determined the distribution of goshawks during winter (Kenward and Widén 1989).

A recent study by Tornberg and Colpaert (2001) monitored the habitat use of 26 radiomarked goshawks in northern Finland. These were birds that were trapped in the winter so their residency status was unknown. However, the species is a resident in the northern boreal forest of Finland. Harmonic mean centers of their winter ranges were concentrated near human settlements where they preyed upon human commensals, e.g., brown rats (*Rattus norvegicus*). Goshawks preferred deciduous and mature coniferous forests and avoided open areas such as large fields and bogs. They also avoided very heterogeneous sites, which the authors attribute to avoidance of areas of dense vegetation and not edges as was noted in Sweden by Widén (1989). In Finland, they preferred small to medium-sized patches (< 30 ha) of forests and avoided large patches (> 30 ha). The results of this study differ from that of Widén (1989) in Sweden where goshawks showed a strong preference for large patches of mature forest. Tornberg and Colpaert suggest these differences are due to differences in prey preferences. Goshawks in Sweden mostly took squirrels, which reached their peak densities in old spruce forests. In Finland, wintering goshawks preyed mostly on species associated with deciduous forests [black grouse (*Tetrao tetrix*)] and early seral stages [mountain hares (*Lepus timidus*)] or urban areas (brown rats).

Within Region 2, Squires and Ruggiero (1995) documented that four goshawks, which nested in south central Wyoming, were short-distance migrants (range = 65–185 km from nesting area). These four goshawks wintered in aspen with mixed conifer stands, large stands of spruce-fir, lodgepole pine and cottonwood groves surrounded by sagebrush.

*Home range size*

The correlation of home range size to habitat use and preference of foraging goshawks is poorly understood for North American populations (Squires and Reynolds 1997). Although comparison of home range sizes may be useful, particularly on a local scale, it is also important to consider prey and foraging habitat abundance and availability, which may be influential factors in home range size (Keane and Morrison 1994, Keane 1999). The distances traveled while foraging and type of hunting habitats preferred and available for the breeding season, dispersal, and winter are critical to developing effective goshawk management plans.

Squires and Reynolds (1997) reported that breeding season home range sizes in North America range from 570-3,500 ha, depending on sex and habitat characteristics. Males' home ranges are usually larger than females (Hargis *et al*. 1994, Kennedy et al. 1994; but see Boal et al. in review). Comparisons among studies are difficult and may not be meaningful due to differences in methodology. Shapes of home ranges vary and may be circular or almost linear depending on habitat configuration and quality (Squires and Reynolds 1997).

Breeding season home range sizes reported for goshawks in North America range from approximately 500 to 4,000 ha depending on sex, habitat, estimation method and data collection method (Austin 1993, Hargis et al. 1994, Kennedy et al. 1994, Iverson et al. 1996, Boal et al. in review). T. Bloxton and J. Marzluff (unpublished data) recently studied the influence of an unusually strong La Niña event (occurred in late 1998/ early 1999 and caused unusually high levels of winter precipitation followed by a cold spring) on prey abundance, space use and demography of northern goshawks breeding in western Washington from 1996-2000. They noted a decline in abundance indices (not modified by detection probabilities) of nine prey species following the La Niña event. Home range sizes more than doubled during this time period suggesting that weather can also have a major influence on home range size via modification of prey abundance.

In the few studies that have estimated winter ranges, they were larger on average than breeding season ranges. In northern Finland, range size was 3,283 - 9,894 ha for males (n = 4) and 2,753 - 6,282 ha for females (n = 11). The variation in range was due to different estimators. The average size of core use winter ranges of 12 goshawks wintering in Utah was 2,580 ha $\pm$ 2530 ha (Stephens 2001). Winter range size was highly variable as it ranged from 1,000 – 7,950 ha. Stephens attributed the large variance to three of the goshawks that wintered in landscapes fragmented by agriculture, where home ranges were very large (2,610 – 7,950 ha).

A study of goshawks in Sweden reported that goshawk winter range size was an inverse function of prey availability (Kenward et al. 1981). At Fortuna, Sweden where pheasants are regularly released, the average goshawk winter home range was 2,000 ha while at Segersjo, where only wild pheasants were present, the average winter range was 5,400 ha (Kenward et al. 1981).

No home range estimates are available for Region 2.

## Feeding habits and prey ecology

*Does food limit goshawk populations?*

Prey abundance and availability are important habitat attributes and potential limiting factors for goshawk populations (Ward and Kennedy 1996, Squires and Reynolds 1997, Kennedy and Andersen 1999, Dewey and Kennedy 2001). In a review of existing literature, Squires and Reynolds (1997) reported prey abundance strongly affects breeding area occupancy and productivity. Ward and Kennedy (1996; New Mexico) and Dewey and Kennedy (2001; Utah), however, experimentally determined that goshawks have a demographic response to a super-abundance of available food during some years, but not during other years, suggesting food is not always limiting during the breeding season. These results have not been tested in Region 2, but similar results from two different regions indicate they are probably applicable rangewide.

These results also suggest that if regional goshawk populations are cyclic, they may only be food-limited during periodic ecological "crunches" when cyclic prey species populations are at low densities (Kennedy and Andersen 1999).

Correlative evidence from North America and Europe suggests goshawk reproduction may be related to the abundance of cyclic prey populations (southern coast of Finland: Lindén and Wikman 1983; southwestern Yukon: Doyle and Smith 1994, Doyle 2000; northeastern Wisconsin: Erdman et al. 1998), primarily, snowshoe hare and grouse (various species). The most dramatic example of this relationship occurred in the Yukon where goshawks breeding in peak snowshoe hare years fledged 2.8 young/active nest and 3.9 young/successful nest, compared to years when hare populations were at their lows, and no active goshawk nests were located (Doyle and Smith 1994). Overall, it appears that certain prey items may be particularly important for goshawk reproduction and abundance of these prey items may influence their reproductive success (Tornberg and Sulkava 1991).

Food limitation can also result in direct starvation of adults. Although this has not been tested experimentally, adult survival of goshawks breeding in western Washington was reduced by approximately 36% following a La Niña winter. Abundance indices of 9 prey species declined during this time period which suggests a climate-mediated food limitation occurred. Reproduction in this area virtually ceased during the 2 years following the La Niña winter (T. D. Bloxton, J. M. Marzluff, and D. E. Varland, unpublished data).

In addition to prey abundance, it is also important to consider whether prey items are *available* to goshawks. For example, even a high abundance of hares may have low availability to goshawks in a dense aspen regeneration area where goshawks are unable to fly or hunt (Dick and Plumpton 1998). Thus, preferences in goshawk foraging habitat are likely determined, in part, by prey availability as well as abundance (Reynolds et al. 1992, Drennan and Beier in press).

Based on the assumption that goshawk populations are regulated by food availability, the *Management Recommendations for the Northern Goshawk in the Southwestern U.S.* emphasizes managing goshawk landscapes to maintain habitat for typical goshawk prey items, as well as nesting and foraging areas (Reynolds et al. 1992). Forest management practices may strongly influence the availability of prey items for the goshawk, thus being a determining factor in the long-term persistence of the species (Kennedy and Andersen 1999). Beier and Drennan (1997) and Drennan and Beier (in press) found goshawks did not select foraging areas based on prey abundance, but rather selected areas with higher canopy closure, greater tree density, and greater density of trees than on contrast plots. They suggest "goshawk morphology and behavior are adapted for hunting in moderately dense, mature forests, and that prey availability is more important than prey density in habitat selection" (Beier and Drennan 1997, Drennan and Beier in press). Drennan and Beier (in press) also suggest that goshawk habitat selection may be a two-tiered process. Their results indicate that wintering goshawks expand and shift their range into habitats where they have access to a more abundant population of large-bodied prey. Thus, they hypothesize that goshawks probably do respond to prey abundance when locating a home range within a large landscape, but select for moderately dense, mature forests where they can use their maneuverability to capture prey when foraging within a home range and habitat type (Beier and Drennan 1997, Drennan and Beier in press).

Although Reynolds et al. (1992) emphasized goshawk prey species depend on a variety of habitats distributed in a mosaic across the landscape, several studies have shown that goshawk prey such as sciurids (Carey et al. 1992, Carey 1995) and birds (Schwab and Sinclair 1994) are more abundant in old-growth and mature forests in comparison to younger forests or managed second growth stands. Arthropods, the prey base for many forest-dwelling insectivores, which may in turn be prey for goshawks, are significantly less abundant along edges and in small woodlots (Burke and Nol 1998, Zanette et al. 2000), suggesting food supplies may be reduced by forest fragmentation. Carey et al. (1992) and Carey (1995) demonstrated that sciurid populations were more abundant and remained at relatively constant levels in old-growth forests in comparison to managed second growth stands. Similarly, Schwab and Sinclair (1994) reported avian populations were more abundant and diverse in mature forests than in younger forests. Recently, Burke and Nol (1998) also reported a significant reduction in invertebrates along edges and in small woodlots as compared to large woodlots further suggesting food supplies may be reduced by forest fragmentation. However, Sallabanks et al. (2001) found little evidence of structural class specializations by breeding birds in grand fir (*Abies grandis*) forests in northeastern Oregon.

Clearly, understanding how prey species are influenced by changes in forest structure and pattern resulting from forest management practices in Region 2 is critical to the development of sound goshawk conservation plans. To develop sound species conservation plans for forest-dwelling birds, it is critical to understand how forest management practices influence prey species by changing forest structure and pattern (Kennedy and Andersen 1999). This information has not been interpreted for Region 2 because the appropriate data are not available.

### *Prey taxa and abundance in diets*

Depending on region, season, and availability, the goshawk captures a wide variety of prey and is classified as a prey generalist (Squires and Reynolds 1997), typically preying on a suite of 8 to 15 species (Reynolds et al. 1992). As with other raptors, the food habits of goshawks have been determined by examination of stomach contents and food removed from crops of nestlings, or more commonly, direct observation of nests, prey remains, and regurgitated pellets (Lewis 2001). Potential biases exist in most of these raptor food habits methods and these biases in accipiter diets are well summarized by Bielefeldt et al. (1992), Younk and Bechard (1994), and Watson et al. (1998).

Although breeding season diet composition has been studied for many populations, little is known about winter diets of goshawk populations in North America. In northern Arizona, Drennan and Beier (in press) found winter diets were dissimilar to summer ones, in part because of the absence of hibernating species, and also noted that individual goshawks may specialize on specific species in the winter. In this area a wintering goshawks appeared to specialize on only 2 species of large-bodied prey, cottontails (*Sylvilagus* spp.) and Abert's squirrels (*Sciurus aberti*).

Although a quantitative study of goshawk prey items in Region 2 has not been published, a few qualitative studies have been conducted on breeding season diet. These reports indicate goshawks in Region 2 eat a wide variety of prey species. This information should be interpreted cautiously because these prey use reports were compiled from a variety of sources. Future diet studies should be planned carefully to address methodological bias in food habits analyses. In addition, all prey observations in Region 2 have been made during the nesting season, thus prey use, availability, and abundance during the winter should also be examined. **Table 9** lists the goshawk prey species reported in Region 2.

Goshawk diets vary among populations with seasonal and regional prey availability. More than 30 species of mammalian and 53 species of avian prey have been identified in diets from goshawk populations in North America (**Table 10**; Squires and Reynolds 1997, USFWS 1998b). A few prey groups are particularly important to most goshawk populations: gallinaceous birds (primarily grouse and pheasants), sciurids (including chipmunks, tree and ground squirrels), lagomorphs, corvids, and woodpeckers. A summary by the USFWS (1998b) lists the following prey species as particularly important to the goshawk throughout its range: chipmunks (*Tamias* spp.), cottontail rabbit (*Sylvilagus* spp.), snowshoe hare, Douglas squirrel (*Tamiasciurus douglasi*), red squirrel (*Tamiasciurus hudsonicus*), golden-mantled ground squirrel (*Citellus lateralis*), gray squirrel, northern flying squirrel (*Glaucomus sabrinus*), American robin (*Turdus migratorius*), blue jay (*Cyanocitta cristata*), Steller's jay (*Cyanocitta stelleri*), ruffed and blue grouse (*Dendragapus obscurus*), common crow (*Corvus brachyrhynchos*), domestic pigeon (*Columba* spp.), and northern flicker (*Colaptes auratus*). Most of these prey groups have been recorded as goshawk prey in Region 2 (**Table 9**).

**Table 9.** Common and less common[1] mammalian and avian prey items of northern goshawks in Region 2 states. Data are listed by source.

| | |
|---|---|
| **Colorado** | |
| **Bergstrom 1985[2,3]** | |
| Mammals | **Birds** |
| Common | *Common* |
| N/A | N/A |
| *Less common* | *Less common* |
| N/A | Blue-winged Teal (*Anas discors*) |
| **Pfeifer 1980[4]** | |
| **Mammals** | **Birds** |
| Wyoming Ground Squirrel (*Spermophilus elegans elegans*) | **None** |
| **South Dakota** | |
| **Bartelt 1977[5,6,7]** | |
| **Mammals** | **Birds** |
| *Common* | *Common* |
| Red Squirrel (*Tamiasciurus hudsonicus*) | Ruffed Grouse (*Bonasa umbellus*) |
| Least Chipmunk (*Tamias minimus*) | Wild Turkey (*Meleagris gallopavo*) |
| White-tailed Jackrabbit (*Lepus townsendii*) | American Robin (*Turdus migratorius*) |
| Mountain Cottontail (*Sylvilagus nuttallii*) | Gray Jay (*Perisoreus canadensis*) |
| | Dark-eyed Junco (*Junco hyemalis*) |
| *Less common* | *Less common* |
| Masked Shrew (*Sorex cinereus*) | None listed |
| Thirteen-lined Ground Squirrel (*Spermophilus tridecemlineatus*) | |
| Northern Flying Squirrel (*Glaucomus sabrinus*) | |
| Woodrat (*Neotoma cinerea*) | |
| Northern Pocket Gopher (*Thomomys talpoides*) | |
| House Mouse (*Mus musculus*) | |
| Norway Rat (*Rattus norvegicus*) | |
| **Wyoming** | |
| **Squires 2000[8]** | |
| **Mammals** | **Birds** |
| *Common* | *Common* |
| Red Squirrel (*Tamiasciurus hudsonicus*) | American Kestrel (*Falco sparverius*) |
| Golden-mantled Ground Squirrel (*Spermophilus lateralis*) | Northern Flicker (*Colaptes auratus*) |
| Uinta or Least Chipmunk (*Tamias* spp.) | Steller's Jay (*Cyanocitta stelleri*) |
| Deer Mouse (*Peromyscus maniculatus*) | American Robin (*Turdus migratorius*) |
| Red-backed Vole (*Clethrionomys gapperi*) | Black-headed Grosbeak (*Pheucticus melanocephalus*) |

**Table 9.** Concluded.

| | |
|---|---|
| *Less common* | *Less common* |
| Montane Vole (*Microtus montanus*) | Red-naped Sapsucker (*Sphyrapicus nuchalis*) |
| Snowshoe Hare (*Lepus americanus*) | Pine Siskin (*Carduelis pinus*) |
| American Marten (*Martes americana*) | Townsend's Solitaire (*Myadestes townsendi*) |
| Long-tailed Vole (*Microtus longicaudius*) | Dark-eyed Junco (*Junco hyemalis*) |
| Mule Deer (*Odocoileus hemionus*) | Evening Grosbeak (*Coccothraustes vespertinus*) |
| Western Jumping Mouse (*Zapus princeps*) | Hairy Woodpecker (*Picoides villosus*) |
| Ermine (*Mustela erminea*) | Pine Grosbeak (*Pinicola enucleator*) |
| Richarson's Ground Squirrel (*Spermophilus richardsonii*) | Ruffed Grouse (*Bonasa umbellus*) |
| | Western Tanager (*Piranga ludoviciana*) |
| | Gray Jay (*Perisoreus canadensis*) |
| | Mountain Bluebird (*Sialia currucoides*) |
| | Red Crossbill (*Loxia curvirostra*) |
| | Three-toed Woodpecker (*Picoides tridactylus*) |
| | Black-billed Magpie (Pica pica) |

[1]Common prey items were the top five most abundant species found in the diet in each study. Less common indicates all other prey items.

[2]Methodology - direct observation.

[3]An observational record with no study conducted hence regarded as less common avian prey item and N/A for common avian, common and less common mammalian prey items.

[4] She observed 14 aerial kills of this ground squirrel by goshawks while investigating ground squirrel social behavior.

[5]Methodology - prey remains analysis.

[6]Methodology - pellet analysis.

[7]Abundances of prey items varied with nest location. Author did not present a table that summarized means across nests so these values are based on text presented in the Discussion, which focused on the top four species.

[8]45% of all prey items were classified as unknown.

**Table 10.** Proportions of mammalian and avian prey items in northern goshawk diets.

| Location | Method(s)[1] | % Mammals in diet[2] | % Birds in diet[2] | Source |
|---|---|---|---|---|
| Europe | | | | |
| England | R | 12 (33)[3] | 88 (67)[3] | Toyne 1996[4] |
| Finland | O | 5 | 95 | Bergman 1961[5] |
| | P,R | 10 - 20 | 80 - 90 | Wikman and Tarsa 1980[6] |
| | R | 14 -15 | 85 - 86[7] | Huhtala and Sulkava 1981 |
| | R | 12 - 16 (11 - 17)[3,8] | 88 - 84 (83 - 89)[3,8] | Tornberg and Sulkava 1990 |
| | R | 15 - 26 (11 - 32)[3,9] | 74 - 85 (68 - 89)[3,9] | Tornberg 1997 |
| | P,O,R | 71 (77)[3,10] | 27 (23)[3,10] | Tornberg and Colpaert 2001 |
| Germany | R | 15 | 15 | Brull 1964 |
| | R | 2[4] | 98[4] | Dietrich and Ellenberg 1981 |
| Italy | P,R | 25 (29)[3] | 75 (71)[3] | Penteriani 1997 |
| Netherlands | R | 2 | 98 | Opdam 1975 |
| | R | 4 | 96 | Opdam et al. 1977 |
| Norway | Unknown[5] | 25 | 75 | Bergman 1961[5] |
| | R | 8 | 92 | Myrberget 1989 |
| Poland | P,R | 9 (5)[3] | 91 (95)[3] | Goszczynski and Pilatowski 1986 |
| Spain | P,R | 23 (43)[3,11] | 76 (57)[3,11] | Manosa 1994 |
| Sweden | R | 14 | 86 | Widen 1987 |
| | O | 47[12] | 38[12] | Kenward et al. 1981 |
| North America | | | | |
| United States: | | | | |
| Alaska | O | 27 (26)[3] | 73 (74)[3] | Lewis, 2001 |
| | P,O,R | 78 (90)[3,12] | 21 (10) [3,12] | Zachel 1985 |
| Arizona | R | 76 (94)[3] | 24 (6)[3] | Boal and Mannan 1994 |
| | P,R | 62 | 38 | Reynolds et al. 1994 |
| California | P,O,R | 25 (37)[3] | 75 (63)[3] | Schnell 1958 |
| | R | 29 – 78[13] | 22 – 71[13] | Woodbridge et al. 1985 |
| | Unknown[14] | 52 (69)[3] | 48 (31)[3] | Bloom et al. 1986 |
| | P,O,R | 59[11] | 39[11] | Root and DeSimone 1978 |
| Connecticut | P,R | 17 | 83 | Bosakowski et al. 1992[15] |
| | R | 34 | 66 | Bosakowski and Smith 1992[15] |
| Idaho | P,O,R | 54 (59)[3] | 46 (41)[3] | Patla 1997[15] |
| Nevada | O | 67 | 32 | Younk and Bechard 1994 |
| New Jersey | R | 34 | 66 | Bosakowski and Smith 1992[15] |
| | P,R | 30 | 70 | Bosakowski et al. 1992[15] |
| New Mexico | P | 49 | 51 | Kennedy 1991 |
| New York | P,R | 39 | 61 | Meng 1959[15] |
| | R | 39 | 61 | Grzybowski and Eaton 1976 |
| | O | 73[12] | 14[12] | Allen 1978 |
| | R | 34 | 66 | Bosakowski and Smith 1992[15] |

**Table 10.** Concluded.

| Location | Method(s)[1] | % Mammals in diet[2] | % Birds in diet[2] | Source |
|---|---|---|---|---|
| Oregon | P,R | 44 | 56 | Reynolds and Meslow 1984 |
| | P,R | 42 | 58 | Bull and Hohmann 1994 |
| | P,R | 38 - 66 (36 - 84)[3,13] | 34 - 62 (38 - 66)[3,13] | DeStefano et al. 1994a |
| Pennsylvania | P,R | 39 | 61 | Meng 1959[15] |
| Utah | R | 91 | 9 | Stephens 2001 |
| Washington | P,R | 50 | 50 | Watson et al. 1998 |
| Wyoming | P,O,R | 54 (59)[3] | 46 (41)[3] | Patla 1997[15] |
| | O | 21 | 79 | Good et al. 2001 |
| Canada: | | | | |
| Alberta | O | 76 (89)[3] | 24 (11)[3] | Schaffer 1998[16] |
| | P,R | 53 (62)[3] | 47 (38)[3] | Schaffer 1998[16] |
| Yukon | R | 22 - 79 (86)[3,17] | 21 - 78 (13)[3,17] | Doyle and Smith 1994 |
| | R | 48 - 90[17] | 10 – 52[17] | Doyle 2000 |

[1]Methods are classified as: P – pellet analysis, R – prey remains, O – direct observation.

[2]Percentages were calculated from original data presented in manuscript. Numbers are rounded to the nearest percent.

[3]Percent biomass appears in parentheses.

[4]Based on visual interpretation of figures so there might be interpolation errors.

[5]Bergman reviews and presents data from studies done by Sulkava (1956) in Finland and by Hagen (1952) in Norway. No descriptions of the study methods are given.

[6]Range of percentages for mammalian prey items only appeared in the text; hence percentages for birds were inferred from these data.

[7]Percentages vary by sampling location; the spatial variation is presented as a range. Entry for southern Ostrobothnia (1949-59) was omitted due to a potential error with percentages adding to more than 100 (Huhtala and Sulkava 1981).

[8]Data are for the courtship and nestling periods; hence, percentages vary seasonally and this seasonal variation is presented as a range.

[9]Data are by breeding season month; hence, percentages vary and the monthly variation is presented as a range.

[10]Percentages don not add to 100 due to presence of “carcass” prey item in diet.

[11]Percentages don’t add to 100 due to presence of reptiles and/or arthropods in diet.

[12]Percentages don’t add to 100 due to the presence of unknown food items.

[13]Precentages vary by sampling location hence percentages vary and this spatial variation is presented as a range.

[14]No methodologies are presented.

[15]Study includes multiple states and thus, appears several times in the table.

[16]Author presented results for direct observations and prey and pellet analyses, hence presented twice in table.

[17]Study conducted over a period of several years hence percentages vary and this temporal variation is presented as a range.

Gallinaceous birds (primarily grouse and pheasants) may be particularly important prey for North American (Mendall 1944, McGowan 1975, Gullion 1981a, b, Gullion and Alm 1983, Apfelbaum and Haney 1984) and European goshawks (Kenward 1979, Sollien 1979 *in* USFWS 1998b, Kenward et al. 1981, Lindén and Wikman 1983, Tornberg 2001) at northern latitudes. Fluctuations in grouse populations have been shown to affect goshawk productivity, including number of nesting pairs, and number of young per active nest (Lindén and Wikman 1983, Sollien 1979 *in* USFWS 1998b). Tornberg et al. (1999) analyzed skin and skeletal measurements collected from 258 museum specimens of Finnish goshawks dated between 1961 and 1997. They reported that as grouse decreased in abundance and thus, in the goshawk diet, and were replaced by smaller prey during the breeding season over this 36-year period, morphological shifts were seen in both males and females as a result of selective pressures due to changes in diet.

Sciurids occur in most goshawk diets due to their high abundance and broad distribution (USFWS 1998b). Several studies have documented red squirrels as important prey (Mendall 1944, Meng 1959, Reynolds et al. 1994) and they may be especially important during the winter when other preys are unavailable (Widén 1987). Rabbits and hares are also used extensively by goshawks (Reynolds and Meslow 1984, Kennedy 1991, USFWS 1998b). Cottontail rabbits are abundant in a variety of habitats and are distributed throughout the goshawk's range (USFWS 1998b) and snowshoe hares are also important prey, particularly in northern forests (Mendall 1944, McGowan 1975, Doyle and Smith 1994). In the Yukon, Doyle and Smith (1994) found a positive correlation between goshawk breeding success and a snowshoe hare population peak Snyder and Wiley 1976, Reynolds and Wight 1978, Lee 1981).

Robins (Grzybowski and Eaton 1976, Reynolds and Meslow 1984, Kennedy 1991), corvids (crows: Meng 1959, Eng and Gullion 1962, Gullion 1981b, Fleming 1987; and jays: Bloom et al. 1986, Beebe 1974 in Squires and Reynolds 1997, Kennedy 1991, Bosakowski et al. 1992, Boal and Mannan 1994), and woodpeckers (Schnell 1958, Eng and Gullion 1962, Erickson 1987, Allen 1978, Reynolds and Meslow 1984, Reynolds et al. 1994) are also common prey items found in many parts of the goshawk's range. Northern flickers are particularly important in many goshawk diets (Grzybowski and Eaton 1976, Reynolds and Meslow 1984, Bloom et al. 1986, Kennedy 1991, Boal and Mannan 1994).

The only published study on goshawk food habits in Region 2 was by Squires (2000). Based on an analysis of 793 regurgitated pellets from 40 active goshawk nests in south central Wyoming (Medicine Bow-Routt National Forest in the Sierra Madre and Medicine Bow Mountain ranges) he concluded goshawks nesting in this area forage primarily on red squirrels, northern flickers, American robins, golden-mantled ground squirrels, and chipmunks. These data suggest the diet of birds in Region 2 does not differ from diets of other western populations.

### *Prey species habitat needs*

Goshawk prey species need a variety of habitat conditions from early to mature seral stages. Reynolds et al. (1992) emphasized goshawk foraging areas should include a variety of habitats and ages to support an abundant prey base. They also suggested goshawk foraging areas in southwestern pine forests be managed for stands that are approximately 2,160 ha surrounding, but not including, nest areas. These stands should include a mosaic of vegetation structural stages interspersed throughout the area and consist approximately of 20% each of old, mature, middle-aged and young forests, 10% in the seedling/sapling stage, and 10% in the grass/forb/shrub stage. The 60% of the stands consisting of older age classes should have relatively open understories with a minimum of 40–60% canopy cover (Reynolds et al. 1992).

Although the species on which goshawks prey vary among forest types and regions, there are a few habitat features that appear to be important to a variety of prey species (Reynolds et al. 1992, USFWS 1998b). These features include snags, downed logs (> 30 cm in diameter and 2.4 m long), large trees (> 46 cm in diameter), openings and associated herbaceous and shrubby vegetation, interspersion, and canopy cover.

Reynolds et al. (1992) also recommended forest areas managed for goshawk prey species include large trees scattered throughout the foraging area. This large tree component, which often occurs in clumps with interlocking crowns, provides various and unique hiding, feeding, denning, and nesting areas used during some part of the annual cycle of all selected goshawk prey species (USFWS 1998b).

Goshawks also hunt species that use early seral stages and openings. Interspersion (the degree of intermixing of vegetation structural stages) and canopy cover have varying effects on different goshawk prey species (Reynolds et al. 1992). For example, red squirrels respond negatively to a high level of interspersion of structural stages and select closed older forests to attain high-density populations. Grouse, on the other hand, respond positively to high interspersion of openings and older forests. Other prey species, such as American robins, are habitat generalists and are abundant in most structural stages (Reynolds et al. 1992).

Reynolds *et al*. (1992) speculated that small to medium openings (< 1.6 ha) and various seral stages scattered throughout goshawk foraging habitat enhance availability of food and habitat resources for prey and limit the negative effect of large openings and fragmentation on distribution and abundance of prey species that use interior forests (USFWS 1998b). Forests ideal for producing prey available for goshawks have well-developed herbaceous and shrubby understories associated with small to medium openings, which provide cover and food for many small mammals and birds in the form of seeds, berries, and foliage.

Reynolds et al. (1992) was a management plan and thus, is an untested hypothesis. These concepts could be developed for Region 2 habitats but it would require modification of the Reynolds et al. (1992) document to Region 2 habitats and prey species requirements. The limited data on Region 2 goshawk diets suggest the species is relying on similar prey. In addition, data provided by Good (1998) on prey habitat use support the conclusions of Reynolds et al. (1992). Of the four dominant prey species in Good's study area in south central Wyoming, (red squirrel, golden-mantled ground squirrels, northern flickers and American robins), red squirrels are the most specialized in habitat use. They are found exclusively in conifer or conifer-aspen forests in this area. The remaining three species are more general in habitat requirements. Northern flickers nest in aspen and conifer forest but forage in forest and open areas. American robins occur in several habitats and require forests or tall shrubs only for nesting. Golden-mantled ground squirrels are found in rocky openings and ledges, but also occur in forests.

*Seasonal dietary shifts*

Most information regarding seasonal changes in the diets of goshawks is based on European studies (Marquiss and Newton 1982, Lindén and Wikman 1983, Tornberg and Sulkava 1990 in USFWS 1998b). In general, at northern latitudes where galliformes are an important source of food, goshawks tend to rely on them heavily in the spring during nest-building and incubation, shifting to other forms of prey such as migrant passerines and woodpeckers when they are raising offspring.

Information about winter diets is scarce and varies geographically with prey base. In Swedish boreal forests, Widén (1987) found birds dominated diets during the breeding season, accounting for 86% of prey numbers and 91% of biomass. However, squirrels dominated both numbers (79%) and biomass (56%) of prey in winters of both high and low squirrel abundance. Drennan and Beier (in press) reported that in contrast to the high prey diversity killed by goshawks in Arizona during the breeding season, goshawks specialized in preying on only two species of large-bodied prey [cottontails and Abert's squirrels] in the winter. They reported that individual goshawks specialized on only one of the two species. Goshawks located in ponderosa pine throughout the winter specialized in killing either cottontails or Abert's squirrels, but not both, and goshawks wintering in pinyon-juniper habitats were found preying on cottontails only. Younk and Bechard (1994) found goshawks in Nevada shifted their diets to include more birds such as American robins and northern flickers when Belding's ground squirrels began to estivate.

Seasonal trends in diet for goshawks in Region 2 are unknown.

*Foraging behavior*

Goshawks and other accipiters exhibit morphological and behavioral adaptations for hunting in forests (Squires and Reynolds 1997). Studies of foraging habitat used by goshawks are based on habitat analyses of kill locations or locations used during foraging. These results suggest they select foraging areas with specific structural characteristics, such as flight corridors between vegetation layers and stands with a high density of large trees (Beier and Drennan 1997, Boal et al. 2002, Drennan and Beier in press).

Accipiters were originally described as sit-and-wait predators (Pianka 1983, Schoener 1971, 1984). These original descriptions were based on limited data because foraging behaviors of free-ranging accipiters were very difficult to study. However, studies on radio-tagged wintering goshawks in Sweden (Kenward 1982, Widén 1984), breeding European sparrow hawks (*A. nisus*) in Great Britain and breeding goshawks in Utah (Fischer 1986) suggested accipiters perch briefly, search for prey from these perches and then move elsewhere if potential prey are not encountered within a few minutes. In one study, only 3% of goshawk attacks on prey were from goshawks already in flight (Kenward 1982). Kennedy (1991) confirmed these results and defined this search strategy as *saltatory searching.* Saltatory searching, as originally described by Evans and O'Brien (1988), is characterized by a stop-and-go pattern where the animal repositions itself frequently to scan from a new location. Both ambush, i.e. sit and wait, and saltatory foragers, search for prey while pausing, unlike cruise foragers, e.g., canids, which search while moving. One of the primary differences between ambush and salutatory foragers is the frequency of repositioning moves (O'Brien et al. 1989, 1990).

Goshawks occasionally hunt by flying rapidly along forest edges and across openings (Squires and Reynolds 1997). Anecdotal observations suggest they will crash through dense vegetation in pursuit of prey and their vigorous and sometimes reckless hunting behavior is legendary among falconers (Beebe 1974). They readily use trees, shrubs, and topographic features to hide from potential prey (Backstrom 1991) and at times stalk prey (Bergstrom 1985). Goshawks have been observed capturing food through dogged persistence in addition to using surprise attacks (Westcott 1964, Brace 1983). Goshawks will even enter water when chasing prey (Schnell 1958, Fulton 1983). Depending on prey type and behavior, goshawk hunting techniques may vary from a smooth, silent, accelerating glide that ends in a strike, to rapid flapping in an attempt to increase its speed toward an animal that has realized it is being pursued (Beebe 1974).

No data on foraging behavior in Region 2 are available for goshawks.

*Foraging success, prey delivery rates and prey caching*

Foraging success and prey delivery rates vary according to type of prey, goshawk hunting experience, and habitat characteristics (USFWS 1998b). Average number of prey items delivered to 2 nests by goshawks was reported as 1.84 and 2.69 deliveries per observation day in the Adirondacks (Allen 1978), 0.25 items/hour at 20 nests in Arizona (Boal and Mannan 1994), 0.31 items per hour at 8 nests in Nevada (Younk and Bechard 1994), and Schnell (1958) reported a prey delivery rate of 3.9 deliveries per day at one nest in California.

In Region 2, average prey delivery rate at 8 nests in south central Wyoming was 0.23 items/hour (Good et al. 2001), which is comparable to the other two studies with large sample sizes (Boal and Mannan 1994, Younk and Bechard 1994). In the Good et al. (2001) study, birds comprised 21.1% and mammals 78.9 % of identified deliveries (n = 38). Red squirrels were the most frequently delivered prey item. Delivery rates varied among nests and males and females made 71% and 29% of deliveries to nests, respectively. Males generally are documented as delivering the majority of prey to nests. However, in the Good et al. (2001) study, females provided a larger proportion of prey deliveries than previously documented. The authors attribute these results to differences in study methods. The Good et al. (2001) study was the first study to combine intensive telemetry efforts with nest observations and thus, could more accurately attribute prey deliveries to a particular bird. Previous studies have assigned the sex of the deliverer solely on visual and auditory cues.

Caching of surplus prey when nestlings are unable to consume entire prey or for future use during periods of low food availability has been recorded in many species of raptors (Newton 1979). In one study (Schnell 1958), a female goshawk was observed caching food for nestlings until they were approximately one month old. Caching rates have not been quantified in this species.

### *Foraging distance from nest*

The distance that males hunt from their nests probably varies by habitat, nesting phenology, and prey density (USFWS 1998b). Kennedy (1988) found male goshawks did not hunt immediately adjacent to the nest, but foraged 0.8–8 km away from it. Schnell (1958) reported one female tended to hunt within a 91–122 m radius of the nest. In Minnesota, of 37 banded ruffed grouse killed by goshawks, 9 were killed approximately 1,097–2,515 m from the goshawk's nest, 26 were killed within a 1.6-km radius, and 32 were killed within a 2-km radius (Eng and Gullion 1962). In south central Wyoming, the mean distance between a nest and a kill site was 1,885m (SD=1,181m). These limited data on foraging distances combined with home range data suggest goshawks hunt over large areas. Male goshawks in Wyoming made kills up to 5,456 m from nests (Good 1998).

## Breeding biology

### *Prelaying period*

Although there are few data available on when courtship behavior commences, Møller (1987) reported copulations by goshawks as early as 52 days prior to egg laying in Denmark. Penteriani (2001) reported a peak in goshawk vocalizations in France during February and March, which "corresponded to initial courtship and territory establishment." The courtship period in Utah and Minnesota is later than in Europe (March – late April) (Dewey et al. in press, Roberson 2001). The phenology of courtship will vary with population residency patterns; resident birds may initiate courtship earlier than migrants (Dewey et al. in press). Goshawks have been observed near their nesting areas in Minnesota (Roberson 2001) and other areas (Lee 1981) as early as late February, but are typically observed for the first time in early to late March (Zirrer 1947, Reynolds and Wight 1978, Widén 1984, Dewey et al. in press). Møller (1987), Palmer (1988), Johnsgard (1990) and Squires and Reynolds (1997) discuss courtship rituals and mating.

Møller (1987) reported goshawk copulations in Denmark peaked twice in the pre-laying period from 31–40 days and from 5–22 days prior to egg laying. There are few observations of nest building, although Schnell (1958) and Lee (1981) reported females do most of the nest building, with males contributing only occasionally. The female goshawk becomes sedentary as egg-laying approaches, presumably to sequester the energy reserves necessary for egg formation (Reynolds 1972, Newton 1979, Lee 1981, Speiser and Bosakowski 1991); the male delivers prey directly to the female during this time. Roberson (2001) found goshawks in Minnesota were responsive to broadcasts of conspecific alarm calls during the courtship period.

### *Breeding period - incubation*

Timing of clutch completion ranges from early April to early June, varying among pairs, geographic areas, and years, but completed on average between late April and mid-May (Reynolds and Wight 1978, Henny et al. 1985, Reynolds et al. 1994, Dewey et al, in press). Replacement clutches appear to be rare, but have been reported at 15–30 days after initial egg loss (Marquiss and Newton 1982).

The incubation period has been estimated at 30–44 days (Brown and Amadon 1968, Snyder and Wiley 1976, Reynolds and Wight 1978, Lee 1981). Differences among estimates may be attributed to individual, geographic, or annual variation, or to measurement error (USFWS 1998b). Eggs are laid at 2–3 day intervals (Squires and Reynolds 1997), with clutch completion time varying with clutch size. Incubation usually begins with the first or second egg laid, resulting in partial asynchronous hatching (hatching a clutch may only take 2-3 days; Squires and Reynolds 1997). Because the female is typically reluctant to leave the nest during this period (Squires and Reynolds 1997), broadcast surveys during this time may elicit little, if any, response and are therefore less effective (Kennedy and Stahlecker 1993).

*Breeding period – nestling phase*

Hatching has been reported from late May through June (Reynolds and Wight 1978, Lee 1981, Dewey et al. in press) but varies considerably. Brood size typically is one to three. On the Kaibab Plateau in Arizona 28% of 224 successful broods had one young, 50% had two young and 22% had three young (Reynolds et al. 1998).

The nestling period varies from 37 to 45 days (Dixon and Dixon 1938, Reynolds and Wight 1978, Newton 1979, Kenward et al. 1993a, Boal 1994, Kennedy and Ward in press) and young generally fledge between late June and late July (Reynolds and Wight 1978, Reynolds et al. 1994, Kennedy and Ward in press), with males developing faster and fledging sooner than females (Reynolds and Wight 1978, Kenward et al. 1993b, Boal 1994).

Females will brood almost continually for 9 to 14 days following hatch (Schnell 1958, Boal 1994, Dewey and Kennedy 2001). Females do most of the brooding, but males may occasionally brood young while the female feeds (Schnell 1958, Lee 1981). The female also does most of the feeding of young, while the male does most of the hunting, at least until late in the nestling period (Squires and Reynolds 1997, Dewey and Kennedy 2001).

The female broods the young and only rarely attacks intruders entering the nest stand during the first few days after hatching (Speiser and Bosakowski 1991). Although there is individual and geographic variation in nest defense behavior, adult females are often aggressive toward human intruders later in the nestling period (Boal and Mannan 1994). Several studies have found response rates to broadcasts of goshawk alarm calls to be high during this period, facilitating detection of nests (Kennedy and Stahlecker 1993, Joy et al. 1994, Watson et al. 1999, McClaren et al. in review); however, Roberson (2001) found in her Minnesota study area, responses to broadcast calls were highly variable among female goshawks during the nestling period. There was more variability in detections during this phase than in other phases appropriate for surveys.

Ward and Kennedy (1996) hypothesized that food supplementation during the nestling and fledgling-depedency periods affected young goshawk survival not by limiting starvation, but by causing the adult female goshawk to modify her behavior and spend increasing time in the nest stand, allowing more constant protection from predators. Dewey and Kennedy (2001) experimentally tested their hypothesis and found female nest attentiveness is a function of food availability in the nest stand.

*Breeding period – fledgling-dependency phase*

This period begins when the young leave the nest, and continues until they are no longer dependent on the adults for food. In New Mexico, this period occurs from early August to early September beginning when the young are approximately 80 days of age and lasting 32-43 days (Kenward et al. 1993a, Kennedy and Ward in press). The fledgling-dependency period is an important period of transition during which the young learn to hunt and protect themselves (Reynolds et al. 1992, USFWS 1998b). Feather growth is not yet complete (Bond 1942, Kenward et al. 1993a), so young are initially incapable of sustained flight and may have special habitat requirements as discussed in the section on Post-fledging area and multi-scale habitat studies.

For the first 3 weeks after fledging, juveniles tend to remain within 300 m of the nest, after which distance from nest tree increases with time until dispersal (Kennedy et al. 1994). Studies evaluating broadcast methods used for goshawk surveys have found fledglings to be responsive to conspecific juvenile food-begging calls during this time (Kennedy and Stahlecker 1993, Roberson 2001). In New Mexico, radio-tagged juveniles were independent at approximately 90 days of age (Kennedy and Ward in press). In Europe, Kenward *et al*. (1993a) documented that males dispersed approximately 7 days earlier than females. See the Natal dispersal section for more details.

*Nonbreeding period*

This period begins when adults are no longer feeding juveniles and ends with the beginning of courtship. This is the least studied and understood period of the goshawk annual cycle thus, there are currently no methods available to survey nonbreeding goshawks.

*Pair fidelity/breeding area fidelity*

Pair fidelity is measured within a season by estimating the degree of extra-pair fertilizations (EPFs) and between seasons by monitoring site occupancy of banded birds. A recent genetic analysis of 103 adults and 122 nestlings from 64 nests in northern Arizona by Gavin et al. (1998) indicate extra-pair fertilizations (EPFs) are infrequent in this population (9.4% in 1991, 0% in 1992 and 1993), a result consistent with characteristics of their mating system. Goshawks are socially monogamous, territorial, noncolonial, synchronously breeding and their nests are far apart, and these characteristics do not promote EPFs.

Between-year pair fidelity to mates is difficult to measure in goshawks because the fate of previous mates is often unknown and fidelity can be confounded by mate replacement due to mortality (USFWS 1998b). Also, because it is often difficult to locate all alternative nest areas, fidelity to breeding areas can be hard to determine. Nonrandom, non-systematic, or incomplete searches may bias results when determining breeding area occupancy.

Detrich and Woodbridge (1994) reported breeding adults in northern California retained the same mate 72% of the time; the 28% of cases in which adults were found paired with new mates could have resulted from death of the previous mate. They also reported that in 3 breeding areas observed for 5 years, 2 males and 2 females bred in three different combinations. Reynolds et al. (1994) reported a mate replacement rate of 23% between 1991 and 1992 in northern Arizona (n = 30).

In northern Arizona out of 259 banded adult goshawks, there were 6 instances of breeding dispersal by males which resulted in a rate of 4.9/100 opportunities, and 11 instances of breeding dispersal by females resulted in a rate of 6.3/100 opportunities (Reynolds et al. 2000). Only 16.7% of breeding dispersals (n = 17) were preceded by nest failure in the prior breeding season, whereas 88.2% of dispersals were preceded by non-return of a mate (Reynolds *et al*. 2000). Most goshawks, however, stayed on their previous year's breeding area despite non-return of mate. Reynolds and Joy (1998) found that breeding area fidelity of males (91.7%) exceeded that of females (78.6%) in Arizona. In northern California, adult males and females occupied the same breeding area in consecutive years 76.5% and 71.4% of the time, respectively (Detrich and Woodbridge 1994).

## Population ecology and viability

Changes in the number of animals in a population over time or space are a function of four demographic parameters: reproduction, survival, immigration, and emigration. Population ecology is concerned with determining how factors such as genetics, population density, distribution, age structure, resource abundance and availability, habitat distribution, competition, and climate influence these population parameters. Understanding population ecology is critical for formulating management plans for a species because of the impact land management practices might have on these demographic parameters via changes in habitat and prey abundance, availability, and distribution (Kennedy 1998).

*Genetics*

Morphometric analyses indicate the species has clinal variation in size and coloration. Size decreases from largest in the Southwestern U.S. north to the Pacific Northwest and the smallest individuals are on the Queen Charlotte Islands. Size then increases from the Pacific Northwest northward through Canada to Alaska (Whaley and White 1994). In British Columbia, wing and culmen length of individuals measured from coastal islands are 2-3% smaller than those of birds from the adjacent mainland (Johnson 1989). Coloration darkens southward and in the Pacific Northwest, involving the extent and blackness of the crown and darkness of gray on back and wings (Squires and Reynolds 1997). Do genetic analyses support this clinal variation noted morphometrically and more importantly, can subspecies and isolated populations be identified?

Published reports of genetic demographic analyses of goshawks are non-existent. Gavin and May (1996) did some preliminary genetic analyses of blood samples in 1992-1994 from: 1) several mountain ranges in southern Arizona and southern New Mexico (within range of *Accipiter gentilis apache*), 2) southeast Alaska (possibly within range of *A. g. laingi*), and 3) several areas within the range of *A. g. atricapillus* (n = 385 blood samples). Estimates of genetic distance indicated populations from Alaska, California, northern New Mexico and northern Arizona were not separated genetically. There is some evidence (albeit weak) the southern Arizona birds, presumably *A. g. apache*, and the one eastern population from Michigan, may be genetically different from the remainder of the birds sampled in North America. The Michigan sample was very small (n = 6) so these data must be interpreted cautiously. There was no indication the birds sampled from Alaska, possibly *A. g. laingi*, were genetically distinct from other western goshawks that are presumably *A. g. atricapillus.* Gavin and May concluded *A. gentilis* in North America does not have as much genetic variation as other birds. These results also suggest gene flow and therefore, dispersal, must be occurring across the populations they sampled in the western U. S. except for populations in southern and northern Arizona. Finally Gavin and May conclude there is no reason to be alarmed about goshawk genetic variability. This low variation is probably normal for this species and there is no evidence to suggest genetic variation is lacking in any particular population due to inbreeding, genetic drift and/or founder effects. These results have not been peer-reviewed and as Gavin and May indicate their conclusions need to be interpreted cautiously because of the low level of genetic variation reported.

Additional genetic analyses are being conducted particularly in the Pacific Northwest where there is concern about the validity of the *laingi* subspecies (E. McClaren, personal communication). Genetic information is not available for Region 2. However, the results of Gavin and May (1996) suggest Region 2 goshawks are probably not genetically isolated from other western populations.

### *Spatial structure*

Spatial structure refers to scale-dependent patterns in which birds distribute themselves over the landscape in relation to food, nest areas, habitat, and conspecifics. Two important aspects of spatial structure are dispersion (the regular spacing of breeding pairs) and density, both of which emphasize local distribution of nesting pairs.

**Dispersion:** Regular dispersion is a consistent characteristic of goshawk populations that likely results from territorial behavior (McGowan 1975, Reynolds and Wight 1978, Widén 1985, Buhler and Oggier 1987 *in* USFWS 1998b, Kennedy 1988, Reynolds et al. 1994, Reynolds and Joy 1998). Mean nearest neighbor distances range from 2.5–6.3 km in Europe (Widén 1985, Buhler and Oggier 1987 *in* USFWS 1998b) and from 3.0–5.6 km in North America (Kennedy 1997).

In Region 2, Shuster (1976) reported a nearest neighbor distance of 2.4 km for six nests in Colorado in 1974. In 1975, with the same sample size, the nearest neighbor distance was 0.8 km. Bartelt (1977) reported nearest neighbor distances of 4 km for the Black Hills in South Dakota.

The regular distribution of nesting pairs documented over many areas could result from habitat distribution and/or territorial behavior (USFWS 1998b). The typical size of a goshawk home range, however, makes defense of the entire area unlikely, and it also seems unlikely that habitat distribution is regular enough to result in such consistent spacing (USFWS 1998b). Mutual avoidance as a result of territoriality seems likely and this spacing behavior may be the mechanism by which goshawk populations adjust their nesting density to resource abundance (Newton 1979). Understanding the mechanism by which goshawks distribute themselves is important because density dependence (Maguire and Call 1992) and spacing behavior may limit the number of pairs an area can support to a level lower than what might be estimated due to availability of food or nest areas (Bernstein et al. 1991).

**Breeding density:** Estimates of goshawk densities are based on either assumed censuses of breeding pairs or the distribution of nearest neighbor distances (USFWS 1998b). Searches for goshawk nests are often conducted only in "suitable" habitat; thus, many studies actually report ecological density (birds per unit of suitable habitat) rather than crude density (birds per unit area; USFWS 1998b). Both techniques rely on several assumptions, including that surveys are complete and accurate. This assumption is problematic because non-breeding birds often go undetected (USFWS 1998b). Estimating nest density by attempts to "census" requires intensive, systematic searches of large areas for nests of goshawks and searches should be repeated over years to detect pairs that do not breed every year (Reynolds and Joy 1998).

Goshawks occur at low densities compared to many avian species (USFWS 1998b). Density estimates from goshawk populations in North America range from less than 1 to 11 pairs per 100 $km^2$ (Kennedy 1997). Densities in the range of 10-11 occupied nests per 100 $km^2$ were reported for three study areas in Arizona, California, and the Yukon (Kennedy 1997).

As Kennedy (1997) noted, in addition to the extensive spatial variation in breeding densities described above, breeding densities can vary annually. Although densities did not vary during two years in one study area in Colorado (Shuster 1976), in three study areas in Oregon, densities varied from 33-270% during 2 years (DeStefano et al. 1994a). The Bly study area censused by DeStefano et al. (1994a) in 1993 was the same study area censused by Reynolds and Wight (1978) in 1974. The number of occupied nest sites located on this study area (n = 4) did not change over the 21 years period and thus densities were equivalent (3.6 birds per 100 $km^2$ in 1974 and 3.8 birds per 100 $km^2$ in 1993; variation due to slightly more area censused in 1974).

In addition to Shuster's (1976) density estimates for Colorado, breeding densities in Region 2 have been estimated for the Black Hills by Bartelt (1977). This was based on nests located from 1972-1976. He estimated densities separately for the northern Black Hills (north of Rapid City, SD) and the southern Black Hills (south of Rapid City, SD) as 0.96 pairs per 100 $km^2$ and 0.36 pairs per 100 $km^2$. However, since the nests only occupied the middle 1/3 of his study area, he estimated ecological densities in these two areas as 2.9 and 1.09 pairs per 100 $km^2$.

**Densities of nonbreeding individuals:** Estimates of goshawk abundance focus on the breeding portion of the population because survey methods are designed to detect breeders. Sampling of nonbreeding individuals during the breeding season requires different methods, and efficient techniques are not available. Nonbreeding individuals may play significant roles in goshawk demography as they do in other species (Newton 1991, Hunt 1997). Nonbreeding individuals may buffer populations during stress, stabilize breeding population abundance by quickly filling in when breeders die, or serve to quickly increase the breeding density during periods of prey abundance (Iverson et al. 1996, Hunt 1997).

Although it is difficult to estimate the proportion of the adult population made up of nonbreeders, several studies in Europe have indicated a substantial portion of the population does not breed (Kenward et al. 1990). Widén (1985) estimated 1/3 of the adult, sedentary population in his Swedish study area was nonbreeding. In Finland, Lindén and Wikman (1983) estimated 35-52% of the goshawks were nonbreeders, with higher proportions occurring during periods of low grouse populations.

**Winter densities:** Winter densities are also difficult to estimate and I am unaware of any winter estimates of density. The only index of winter abundance for North American goshawks was estimated by Doerr and Enderson (1965) for the foothills of the Front Range in Colorado Springs (within Region 2). They operated 6-8 traps in this area from November 14, 1963 to April 14, 1964. All traps traversed a 1,000-m section of jeep trail within the Upper Sonoran and Montane Life Zones. They caught 13 goshawks between November and January. No birds were caught after February 4. The index of abundance ranged from 0.24 – 0.78 goshawks per trap day during this period. The authors concluded goshawks were relatively common in this area until February, after which no birds were present. However, they could have been present but not trappable after one capture. It would be interesting to resample this transect to see if the index has changed.

I am unaware of any other estimates of winter abundance.

**Metapopulation structure:** I am unaware of literature that discusses goshawk population dynamics in a metapopulation framework. Because Region 2 goshawk habitat is relatively continuously distributed, and the scale of use by individual birds is large, regional goshawk populations likely are not structured as a metapopulation. However, this is purely speculative at this point.

*Demographics*

**Age structure:** Based on plumage characteristics, during the breeding season goshawks can be categorized as: 1) subadults (1–2 years) with primarily juvenile feathers; 2) young adults (2–3 years) with primarily adult plumage and some juvenile feathers; and 3) adults (>3 years) with full adult plumage (Bond and Stabler 1941, Mueller and Berger 1968, Henny et al. 1985, Reynolds et al. 1994). Although subadult female goshawks have been observed breeding, no observations of breeding subadult males have been reported (USFWS 1998b) and examination of the testes of subadult males of the European subspecies indicate they are physiologically incapable of breeding (Hoglund 1964).

Reports of subadult birds and juvenile females breeding vary both geographically and temporally. Proportion of subadults and juveniles varied spatially from < 5% (Oregon: Reynolds and Wight (1978); Henny et al. (1985); New Mexico: P. L. Kennedy, unpublished data) to 50% (Nevada: Younk and Bechard 1994). Reynolds et al. (2000) reported the mean age of first breeding for 24 young goshawks recruited into their natal breeding population in Arizona as 3.2 years ± 1.1 (range = 2–5 years) for males and 4.3 ± 1.9 (range = 2 – 8 years) for females. They suggested that low recruitment rates and delayed age of first breeding could indicate a stationary, saturated population of breeders on the study area.

Age structure data are not available for Region 2.

**Reproduction:** Fecundity of goshawks is difficult to measure and thus, various indices of reproductive success have been used. It is important to define the various terminologies used to measure reproductive success in raptors (Steenhof 1987, USFWS 1998b). An *occupied breeding area* is an area with evidence of fidelity or regular use by goshawks that may be exhibiting courtship behavior and may attempt to breed. An *active breeding area* or nest is an area or nest in which eggs are laid. A *successful breeding area* or nest is one in which at least 1 young is fledged. *Nesting success* is the proportion of active nests that fledge at least one young, or occasionally the proportion of occupied breeding areas that fledge at least one young. *Productivity* is the mean number of young fledged per successful nest, the mean number of young produced per active nest, or the number of young per occupied breeding area.

Biases exist in many estimates of these parameters. Reproductive success is often overestimated due to the greater probability of detecting breeding versus non-breeding pairs and successful versus unsuccessful nests (Reynolds and Joy 1998, USFWS 1998b).

*Proportion of pairs breeding:* Few data exist on proportion of pairs attempting to nest annually (USFWS 1998b). Widén (1985) reported 67% of adults radio-tagged (n = 12) during winter in Sweden were later found breeding. In northern Arizona, Reynolds and Joy (1998) found the proportion of pairs (n = 478 breeding area-years) annually laying eggs declined from 77–87% in 1991–93 to 22–49% in 1994–96 with low rates likely occurring during periods of low prey abundance.

No regional information exists on this topic.

*Clutch size:* In Alaska, clutch size ranged from 3.0–3.8 (mean = 3.2; 1971–1973) and no clutches of 5 or more eggs were observed (McGowan 1975). Estimates of mean clutch size were 3.75 in Utah (Reynolds and Wight 1978) and 3.2 in Oregon (Lee 1981).

Clutch size information for Region 2 is unavailable.

*Nesting success:* Estimates of annual nesting success range from 8–94% (Squires and Reynolds 1997, Lapinski 2000, Boal et al. 2002). West of the 100$^{th}$ meridian, mean nest success ranges from 76 – 95% (**Table 11**). The one estimate for Region 2 (Bartelt 1977) is within the range of variation reported for this species. Most estimates of nesting success are probably biased because successful nests are more readily detectable than failed ones (Mayfield 1961, Miller and Johnson 1978, Johnson 1979, Hensler and Nichols 1981, Steenhof and Kochert 1982, Manolis et al. 2000).

Causes of nest failure include human disturbance, i.e., shooting of adults, recreational use of an area, and tree harvest activities (Hoglund 1964, Hennessy 1978, Buhler et al. 1987); great horned owl and goshawk predation (Hennessy 1978, Ward and Kennedy 1996); mammalian predation (McGowan 1975, Hennessy 1978, Doyle and Smith 1994, Erdman et al. 1998); disease (McGowan 1975, Ward and Kennedy 1996); and inclement weather (Hennessy 1978, Boal et al. 2002). Food limitation can result in higher predation rates on nestlings because female goshawks must spend more time foraging and less time defending their young (Ward and Kennedy 1996, Dewey and Kennedy 2001).

*Productivity:* Productivity, defined as the number of young fledged per nest where eggs were laid, is the most commonly used statistic quantifying raptor reproduction (Newton 1979). It is also common to consider young observed at 80-90 % of fledging age (bandable young) as surviving to fledge (Steenhof 1987). Kennedy (1997) defined productivity as the mean number of bandable young produced per occupied breeding area. Standardization of terminology and techniques and reliable estimates of variability are important for comparisons among data sets (Steenhof 1987).

Productivity ranges from 1.2–2.0 young per active nest and 1.4 – 2.7 young per successful nest in western North America (**Table 11**). I did not summarize reproductive success data for the species' range because there are sufficient data for this area to portray the patterns. The highest estimates of productivity in North America are from the northern portion of the goshawk's range in Yukon, Canada and interior Alaska (McGowan 1975, Doyle and Smith 1994). The one estimate of productivity for Region 2 (Bartelt 1977) is within the range of variation noted for this species.

Erdman *et al*. (1998) summarized productivity for their sample of goshawks nesting in northeastern Wisconsin from 1968–1992. This is the longest dataset published on reproduction for any goshawk population. Fledglings per nesting attempt ranged from a high of 3.2 in 1978 to lows of 0.8 in 1983 and 1989. They found annual productivity was directly related to an uncalibrated prey index they developed (it is based on prey remains and pellets containing snowshoe hare and ruffed grouse).

In long-lived raptors, research suggests some nest areas consistently fledge more young than others, with the majority of young in the population being produced by a few females that are breeding in high quality nest areas. McClaren et al. (2002) evaluated whether or not number of young fledged varied spatially and temporally among goshawk nest areas within three study areas where long-term reproductive data from goshawks were available: 1) Vancouver Island, British Columbia; 2) Jemez Mountains, New Mexico; and 3) Uinta Mountains, Utah. A mixed-model ANOVA analysis indicated minimal spatial variation in nest productivity within the three study locations (**Figure 13**). Rather, nest areas exhibited high temporal variability in nest productivity within each study area (**Figure 14**). These results suggest temporal patterns, such as local weather and fluctuating prey populations, influenced goshawk reproduction more than spatial patterns such as habitat characteristics. They concluded nest productivity may inadequately reflect spatial patterns in goshawk reproduction; spatial variability among nest areas in adult and juvenile survival rates may instead reflect variation in habitat quality.

**Survival:** Few data exist regarding goshawk mortality and temporal trends in survival have not been adequately evaluated (Kennedy 1997). Braun et al. (1996) reported that a large portion of observed annual

**Table 11.** Reproduction statistics in western northern goshawk populations in North America. Region 2 data are included.

| Location | Year(s) | No. active nests[1] | No. successful nests[2] | Mean no. young / acctive nest | Mean no. young / successful nest | Mean nest success (%)[3] | Source |
|---|---|---|---|---|---|---|---|
| United States | | | | | | | |
| Alaska | 1971-73 | 33 | NA | 2.00 | 2.70 | NA | McGowan 1975 |
| Alaska | 1991-96 | 56 | 53[4] | 1.90 | 2.00[4] | 95[4] | Titus et al. 1997 |
| Arizona | 1990-92 | 22 | 20 | 1.90 | 2.20 | 91 | Boal & Mannan 1994 |
| Arizona – central | 1990-91 | NA | 23 | NA | 1.72 | NA | Dargan 1991 |
| Arizona – northern | 1988-90 | NA | NA | 1.68 | 2.00 | 82 | Zinn & Tibbitts 1990 |
| Arizona – northern | 1991-96 | 273[4] | 224[4] | 1.55[4] | 1.88[4] | 82[4] | Reynolds & Joy 1998 |
| Arizona – southeastern | 1993-94 | 14 | 11 | 1.50 | 1.90 | 79 | Snyder 1995 |
| California | 1981-83 | 181 | 164[4] | 1.71 | 1.89[4] | 91[4] | Bloom et al. 1986 |
| California | 1987-90 | 23 | 18 | 1.39 | 1.77 | 78 | Austin 1993 |
| California | 1984-92 | 84 | 73[4] | 1.93 | 2.22[4] | 87[4] | Woodbridge & Detrich |
| Idaho | 1989-94 | 68 | 62 | 1.96 | 2.11 | 91 | 1994 |
| New Mexico – northcentral | 1984-95 | 80 | NA | 1.30 | NA | NA | Patla 1997[5] |
| Montana | 1989-94 | 68 | 62 | 1.96 | 2.11 | 91 | McClaren et al. 2002 |
| Oregon | 1992 | 12 | 10 | 1.20 | 1.40 | 83 | Patla 1997[5] |
| Oregon | 1992-93 | 50 | NA | 1.28[4] | NA | NA | Bull & Hohmann 1994 |
| Oregon | 1969-74 | 48 | NA | 1.70 | NA | 90 | DeStefano et al. 1994a |
| Utah – northeastern | 1991-99 | 118 | NA | 1.30 | NA | NA | Reynolds & Wight 1978 |
| South Dakota | 1972 | 17 | 13 | 1.35[4] | 1.77[4] | 76[4] | McClaren et al. 2002 |
| Wyoming | 1989-94 | 68 | 62 | 1.96 | 2.11 | 91 | Bartelt 1977 |
| | | | | | | | Patla 1997[5] |
| Canada | | | | | | | |
| British Columbia - Vancouver Island | 1991-00 | 51 | NA | 1.59 | NA | NA | McClaren et al. 2002 |
| Mean[6] | --- | --- | --- | 1.64 | 1.99 | 86 | --- |

[1]An active nest is one in which at least an egg is laid or is inferred to be laid by a female (e.g., a bird seen in incubation posture).

[2]A successful nest is one that fledges at least one young.

[3]Nesting success is the proportion of active territories that successfully produce young.

[4]Estimated from data presented.

[5]Study done in the Targhee National Forest and encompasses more than one state.

[6]Mean calculated for numeric entries only and not across all studies (i.e. - NA entries were ignored).

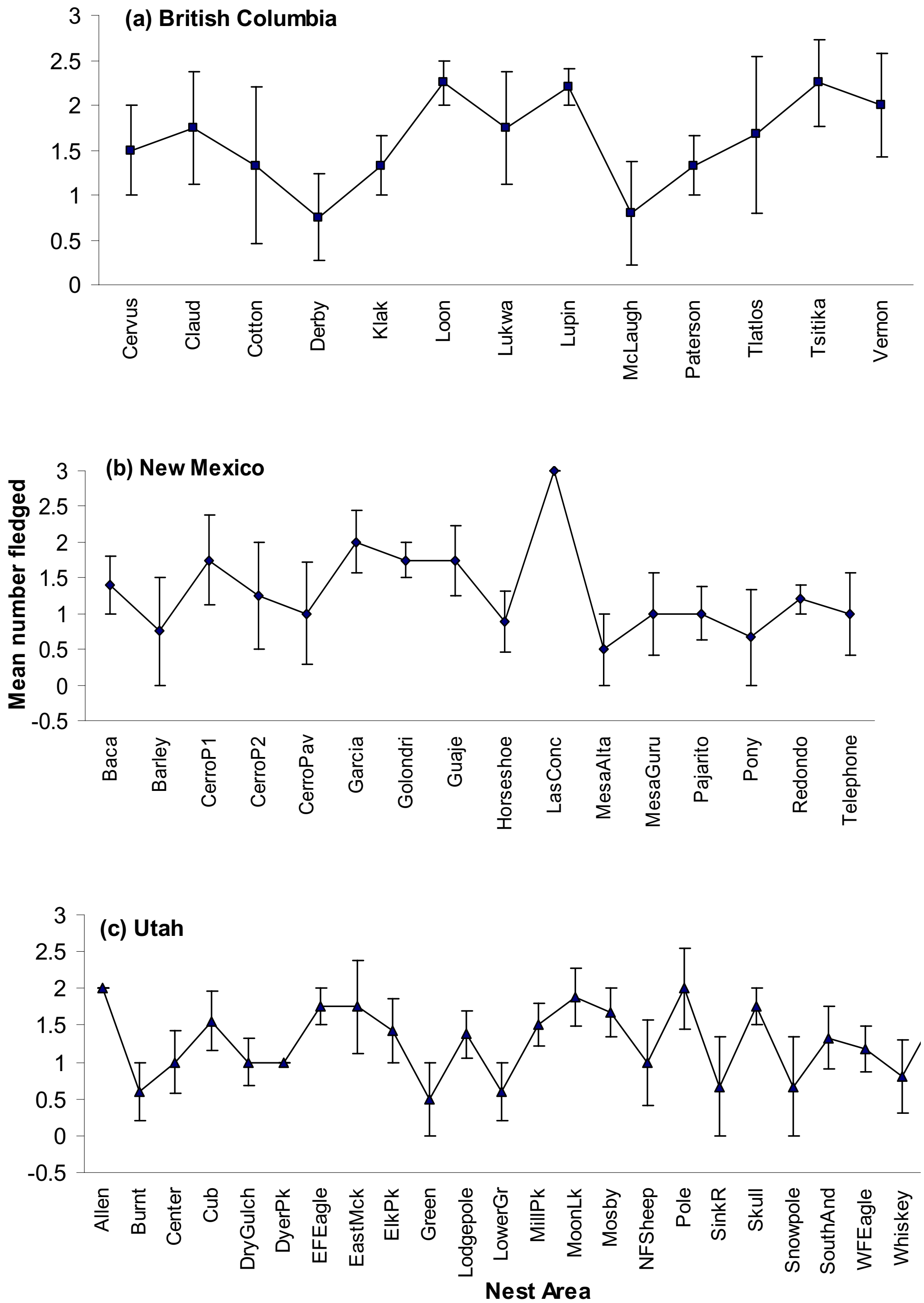


**Figure 13.** Spatial variation (mean ± SE) in the number of young fledged among northern goshawk nest areas within: (a) British Columbia (BC); (b) New Mexico (NM); and (c) Utah (UT). Only nest areas with >3 years of reproductive data are included. From McClaren et al. (2002).

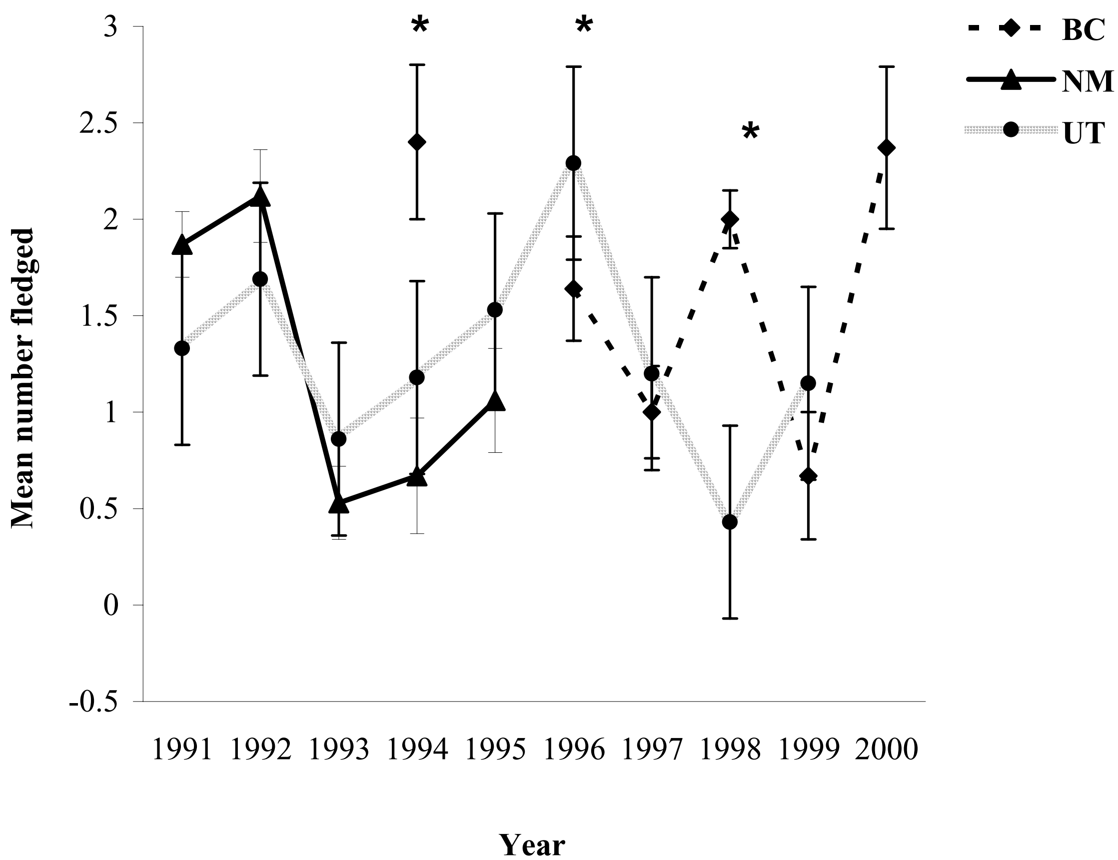


**Figure 14.** Temporal variation (mean ± SE) in the number of northern goshawk young fledged year$^{-1}$ within: (a) British Columbia (BC); (b) New Mexico (NM); and (c) Utah (UT). Data are presented only for periods when at least two study areas sampled goshawk productivity. *Indicates statistical differences of $P < 0.1$. From McClaren et al. (2002).

**Table 12.** Estimated post-fledging survivorship calculated for juvenile (0-1 years of age) northern goshawks.

| Location | Year(s) | Time monitored survivorship (SE)[1] | Annualized survivorship | N | Months post-fledging[2] | Source |
|---|---|---|---|---|---|---|
| North America | | | | | | |
| United States: | | | | | | |
| Alaska | 1992-93 | 0.50 (NA) | 0.16 | 14 | 4.5 | Titus et al. 1994 |
| | 1992 | 0.91 (0.09)[3] | 0.81 | 12 | 5.5 | |
| New Mexico | 1992 | 0.93 (0.06)[4] | 0.85 | 15 | 5.5 | Ward & Kennedy |
| - northern | 1993 | 1.00 (0.0)[3] | 1.00 | 9 | 7 | 1996 |
| | 1993 | 0.67 (0.27)[4] | 0.50 | 3 | 7 | |
| | 1996 | 0.87 (0.1)[3] | 0.56 | 15 | 3 | |
| Utah - | 1996 | 0.89 (0.07)[4] | 0.57 | 18 | 3 | Dewey & Kennedy |
| northeastern | 1997 | 1.00 (0)[3] | 1.00 | 19 | 3 | 2001 |
| | 1997 | 0.56 (0.12)[4] | 0.43 | 18 | 3 | |
| Europe: | | | | | | |
| | 1980-87 | 0.86 (NA) | 0.55 | 22 | 3 | Kenward et al. 1999 |
| Sweden | 1980-87 | 0.69 (NA) | 0.48 | 22 | 6 | |
| | 1980-87 | 0.52 (NA) | 0.52 | 22 | 12 | |
| Fennoscandia | 1950-66 | 0.37 (NA)[5] | 0.37 | 55 | 12 | Haukioja & Haukioja 1970 |
| Finland – northern | 1991-95 | 0.50 (NA) | 0.37 | 7 | 5 | Tornberg & Colpaert 2001 |

[1]Time monitored survivorship is the proportion surviving the number of months indicated (i.e., rates are not annualized).
[2]The number of months monitored after fledging.
[3]Treatment in supplemental feeding experiment.
[4]Control in supplemental feeding experiment.
[5]Estimated from banding.

**Table 13.** Estimated mean survivorship rates for adult female[1] northern goshawks.

| Location | Year(s) | Survivorship (SE) | N | Source | Method |
|---|---|---|---|---|---|
| United States | | | | | |
| Alaska | 1992-96 | 0.72 (NA)[2] | 39 | Iverson et al. 1996 | Radio tracking |
| Arizona - northern | 1991-96 | 0.87 (0.05) | 99 | Reynolds & Joy 1998 | Mark-resight |
| California - northern | 1983-92 | 0.70 (0.10) | 40 | DeStefano et al. 1994b | Mark-resight |
| New Mexico - northern | 1984-95 | 0.86 (0.09)[2] | 45 | Kennedy 1997 | Mark-resight |
| Europe: | | | | | |
| Sweden | 1980-85 | 0.79 (NA) | 132 | Kenward 1999 | Radio tracking |
| Fennoscandia | 1950-66 | 0.86 (NA)[2] | 552 | Haukioja & Haukioja 1970 | Mark-resight |
| Finland - northern | 1991-95 | 0.75 (NA)[2] | 19 | Tornberg & Colpaert 2001 | Radio tracking |

[1]Sufficient data are not available to estimate male survival rates in all studies.
[2]Annual survivorship reported for adults (male and female combined).

mortality occurred outside of the breeding season and was therefore not easily detected.

Annual juvenile survival can vary from 0.16 - 1.00 with most estimates occurring between 0.37 - 0.57 (**Table 12**). Annual adult survival varies from 0.70 - 0.87 (**Table 13**). Using capture-recapture methodology and model selection procedures, DeStefano et al. (1994b) estimated adult survival rates in northern California as 0.61 (SE = 0.05) for males and 0.69 (SE = 0.09) for females. Kennedy (1997) analyzed 12 years of mark-resighting data on 45 adults and estimated the 95% confidence interval of annual adult survival to be 0.60 - 0.96.

Neither juvenile nor adult survival estimates have been estimated for Region 2.

**Longevity:** Age records for wild birds include a six-year-old bird in Alaska (McGowan 1975), five- and seven-year-old birds in northern California (Detrich and Woodbridge 1994), a nine-year-old bird in New Mexico (P. L. Kennedy, unpublished data), an eleven-year-old male in Minnesota (Boal et al. 2002), and a twelve-year-old female in Wisconsin (Evans 1981). Bailey and Niedrach (1965) reported a captive bird living 19 years.

**Causes of mortality:** Goshawks are known to die from a wide variety of causes including accidents, starvation, predation and disease. The degree to which these factors contribute to total mortality have only been reported quantitatively in two studies, Ward and Kennedy (1996) and Dewey and Kennedy (2001), where all radio-tagged juveniles that died in the studies were necropsied for cause of death. In New Mexico 12 necropsied juveniles died of predation (50%), accident (8.3%), spinal injury (8.3%), disease (8.3%) and unknown causes (25%) (Ward and Kennedy 1996). In Utah, 12 necropsied juveniles died of starvation (25%), siblicide (16.7%), accident (8.3%), predation (8.3%), blood loss (8.3%) and unknown causes (33.3%) (Dewey and Kennedy 2001).

Siblicide and cannibalism appear to be infrequent and associated with food deprivation (Schnell 1958). Estes et al. (1999) presented evidence based on observations of siblicide at control nests during a food supplementation experiment that support the hypothesis that siblicide is a mechanism for brood reduction during periods of low food availability. Two observations of cannibalism of goshawk nestlings have been made at nests in Minnesota, but in both cases the factors influencing the cannibalism were unknown (Dick and Plumpton 1998, Boal et al. 2002).

Bloxton et al. (in press) recently reported on two separate causes of apparent choking mortality in adult female goshawks breeding in western Washington. Their evidence suggests the birds died by asphyxiation associated with consuming mammalian prey.

**Climatic influences on demographics:** Interannual variation in demographic parameters is often related to climatic variation (Elkins 1983). Bloxton and his colleagues (unpublished data), demonstrated a profound pattern of reduced survival rates of adult goshawks (with most mortalities occurring during winter) and an almost complete cessation of reproduction after an unusually strong La Niña event. Goshawks generally abandoned reproductive attempts during the pre-laying period or failed during incubation which presumably helped them to improve their body condition throughout the summer. They also documented a decline in prey abundance after the La Niña event. Their results suggest the indirect effects of weather (i.e., reducing prey abundance) are more important than direct effects (i.e., hypothermia, freezing eggs, and reduced foraging caused by precipitation interference) in influencing goshawk populations.

The relationship between goshawk reproduction and weather has also been studied in west-central Germany (Kostrzewa and Kostrzewa 1990, 1991), central Italy (Penteriani 1997), southeastern Idaho/northwestern Wyoming in the U.S. (Patla 1997), and southwestern Yukon in British Columbia (Doyle 2000). In Germany, Italy, and the U. S., high levels of spring precipitation negatively impacted goshawk reproduction whereas warm spring temperatures favored goshawk reproduction. Conversely, in British Columbia high rainfall in May was associated with increased goshawk reproduction. In Germany and British Columbia, there were no relationships between winter weather and breeding success the following season. The relationship between winter weather and subsequent reproduction was not examined in the other 2 locations.

**Population status and viability:** The population models that have been developed for the goshawk were summarized in the section on Population trends. All of these models were for European populations. Erdman et al. (1998) present the only published trend analyses on breeding goshawks in North America. They modeled breeding population trends of goshawks in northeastern Wisconsin from 1971-1992 and included an estimate of annual adult survival (0.80) based on mark-resighting data. The model and methods used for analysis, however, were not thoroughly documented and sample sizes may influence precisions of parameter estimates which were not reported (Kennedy and Andersen 1999).

Based on this undocumented model, Erdman et al. (1998) reported reproduction in goshawks was insufficient to maintain a stationary population and concluded populations are declining in northeastern Wisconsin. However, another study in Wisconsin (Rosenfield et al. 1998) found goshawks nesting widely throughout the northern two-thirds of Wisconsin with no evidence of range contraction, which might be expected if the state's population was declining (Kennedy 1997). Because regional trends in reproduction and survival are not available for goshawks in Region 2, its regional status cannot be evaluated.

In theory Population Viability Analyses (PVAs) are useful tools for managers because they predict risks to a population from various management actions. However, these models require sound estimates of demographics for useful predictions. Most PVAs are not parameterized with appropriate estimates of vital rates and thus, have come under tremendous criticism in the literature (Beissinger and Westphal 1998, Brook et al. 2000, White 2000).

Maguire and Call (1992) developed a PVA for the North Kaibab goshawk population in Arizona. They found the range of variability in parameter estimates, particularly for mortality rates, was so great that their simulation results produced populations ranging from rapidly increasing to rapidly decreasing. They were unable to conclude whether this population was stable, increasing or declining.

Data available on vital rates for goshawks in Region 2 would not support formal development of a PVA. However, the available information can support development of a matrix model and examination of the properties of that model employing sensitivity and elasticity analyses. Through sensitivity analyses I will explore the sensitivity of $\lambda$ (finite rate of population growth) to changes in vital rate values. Elasticity analysis will explore the proportional sensitivity of $\lambda$ resulting from a proportional change in the vital rates. This information suggests which parameters require precise estimates for accurate population predictions.

I developed a simple, 2-stage population matrix model that assumes adult and juvenile survival and fertility do not vary with age (**Figure 15**). The essential feature of matrix models is the organism's life cycle is broken down into a series of stages. Organisms survive from one stage to the next with a given probability (age-specific survival rate) and they produce a given number of offspring. In this model there are two stages, juveniles (age 0-1 years) and adults (> 1 years) and only adults reproduce. In **Figure 15** the straight arrow pointing from Stage 1 to Stage 2 represents the annual juvenile survival rate. The curved arrow pointing from Stage 2 to Stage 1 represents fecundity (the contribution of Age Class 2 to Age Class 1) and the curved arrow originating and ending in Stage 2 represents the annual adult survival (probability of remaining in Stage 2) (Krebs 2000). Although goshawk populations are more realistically modeled by a 3-stage model (including juveniles, subadults, and adults), I could not parameterize this model because survival estimates for 2 adult age classes are not available for any North American population.

Using this model structure and estimates of fecundity and survival from my study area in New Mexico, I used PopTools® Version 2.5 (Build date: October 2002; http://www.cse.csiro.au/poptools/) to estimate population growth rates for this goshawk population. PopTools is an add-in for Windows® versions of Microsoft® Excel 97 2000 and XP that facilitates analysis of matrix population models and simulation of stochastic processes. PopTools was developed by Greg Hood at the Pest Animal Control Cooperative Research Centre, CSIRO, Canberra, Australia. For each time step (years), the model estimated female population size and λ for females. I performed 50 simulations for 50 years.

The demographic inputs were: 1) fecundity for Age Class 1 (0), 2) fecundity for Age Class 2 (0.115, SD = 0.1203 – number of female young produced per female), 3) juvenile female survival (described above) and 4) adult female survival [0.86, SD = 0.09 (Kennedy 1997)] (**Table 14**). Fecundity for Age Class 2 was estimated as the average # young/active nest from Kennedy 1997 (0.94, SD = 0.94). This number was modified by assuming a 50:50 sex ratio of young (0.47 female young produced per active nest) and assuming 35.7% of adult females breed. Proportions of breeding females have not been estimated in North America so I estimated this value from the pooled proportions of radio tagged subadults and adults observed breeding in Sweden (Kenward et al. 1999). The estimate of female young produced per breeding female is 0.17. This number was then multiplied by average juvenile survival (0.675, SD = 0.12032) for control juveniles in northern New Mexico (**Table 12**).

Both the sensitivity and elasticity analyses of these data (**Table 14**) indicate that λ is generally far more sensitive to absolute and proportional changes in adult survival than to changes in other demographic parameters, including juvenile survival. This supports the pattern generally seen in birds where the greatest contribution of adult survival rate to λ occurred among long-lived species such as the goshawk that matured late and laid few eggs (Saether and Bakke 2000). This suggests that monitoring adult survival is more important for estimating population health than monitoring reproduction in goshawks. It also suggests that managing to enhance adult survival might be a better strategy than managing to enhance reproduction. The high elasticity and sensitivity of λ to adult survival does not mean that fecundity is unimportant; but most goshawk monitoring focuses on monitoring reproduction and our efforts need to incorporate monitoring survival if we are going to estimate population trends (McClaren et al. 2002). However, none of the analyses evaluates the influence of model structure on the prediction of λ. So if model structure is flawed, e.g., too simple and unrealistic, this is not evaluated in this procedure.

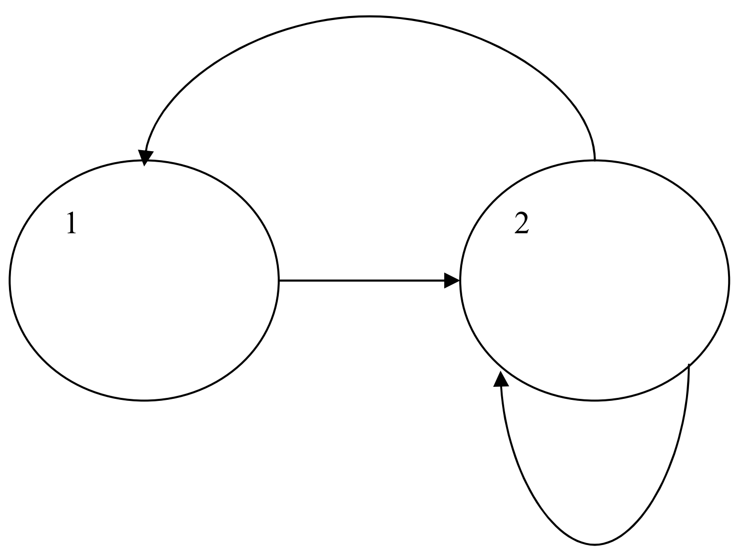


**Figure 15.** A 2-stage population projection matrix for the goshawk. Age class 1 is juveniles (0-1 years of age) and Age Class 2 is adults (> 1 years of age). Only adults reproduce. Model details are provided in the text.

**Table 14.** Results of sensitivity (and elasticity) analyses of 2-stage, stochastic projection model developed for the northern goshawk based on demographic data from New Mexico. See text for details.

| | Age Class 1 (0-1 years age) | Age Class 2 (> 1 years) |
|---|---|---|
| Input Value | | |
| Fecundity | 0.00 | 0.115 (0.120) |
| Female survival | 0.675 (0.128) | 0.86 (0.09) |
| Output Value | | |
| Fecundity | 0.00 (0.00) | 0.66 (0.08) |
| Female survival | 0.11 (0.08) | 0.92 (0.84) |

**Habitat-demographic linkages:** In their status review, the USFWS (1998b) affirmed the general idea that there should be a relationship between changes in forest habitat and change in goshawk populations. They noted there was a correlation between habitat abundance and goshawk home range occupancy for a few local areas (e.g., Crocker-Bedford 1990, Desimone 1997) but no trends were apparent rangewide. Since the status review, two studies have investigated associations between goshawk habitat and demographics in western North America (Finn et al. in press, McGrath et al. in press). Finn et al. (in press) compared forest stand attributes at all known historically occupied nest sites on the Olympic Peninsula, Washington. They measured 45 forest characteristics in nest stands at 30 historical sites. They found goshawks were most likely to occupy historical nest sites with high overstory depth (maximum overstory height – minimum overstory depth) and low shrub cover. Values for some habitat features (i.e., percent shrub cover, percent canopy closure and total snags per ha) were near or within the range of values reported for northern spotted owls (*Strix occidentalis occidentalis*) in young forests on the Olympic Peninsula.

In their multi-scale analysis of goshawk habitat in eastern Oregon and Washington, McGrath et al. (in press) explored relationships between productivity and habitat conditions. Fledging rate in 1994 (they only collected 1 years of productivity data) at their sample of 81 nest sites increased slightly as basal area increased at the 1-ha nest site (The smallest scale in this study). Relationships between productivity and other habitat variables were weak or nonexistent. Their results support McClaren et al. (2002) who demonstrated that variation in goshawk productivity is influenced more by temporal variation, e.g., weather, prey abundance, then spatial variation, e.g., nest habitat characteristics.

## Community ecology

### *Predation*

**Do goshawks regulate prey populations?** The role of predators in limiting or regulating prey populations has recently become a hot topic in research (e.g., Korpimäki and Krebs 1996, Krebs 1996, Redpath and Thirgood 1999, Thirgood et al. 2000, Tornberg 2001). As noted in earlier sections, goshawks are a significant predator of forest-dwelling birds and small mammals. In areas where they are abundant, they could potentially regulate populations of their prey, particularly in areas where they specialize on a few prey species, e.g., boreal forests.

Goshawk predation has been found to play a major role in grouse demography in Europe (e.g., Angelstam 1984, Wegge et al. 1990, Swenson 1991, Valkeajärvi and Ijäs 1994). Two studies have estimated goshawks remove roughly 15-25% of the grouse population during the breeding season (Lindén and Wikman 1983, Widén 1987). Recently Tornberg (2001) studied predator-prey relationships between goshawk and 4 species of forest grouse in northern Finland during 1988-1998. His objective was to evaluate the impact of goshawk predation on grouse numbers and multiannual cycling patterns. Four grouse species constituted > 40% of the goshawk diet during the breeding season. The impact of goshawk predation on grouse varied by species. Losses were highest for willow grouse (*Lagopus lagopus*) and lowest for capercaillie (*Tetrao urogallus*). On average goshawks took 6% of grouse chicks. On an annual basis breeding goshawks took

2-31% of the August grouse population. The most reliable estimates of the goshawk's share of grouse total mortality were for black grouse (*Tetrao tetrix*) and hazel grouse (*Bonasa bonasia*) of which 35% and 40% were removed, respectively. He also provided evidence for a weak functional and numerical response in goshawks to changes in grouse densities.

The role of goshawk prey regulation in southern latitudes where they are more prey generalists is unknown. Also, information on goshawk impacts on North American prey populations is nonexistent.

**Goshawks as prey:** As mentioned in the section on Causes of mortality, goshawks are also prey items and thus, potentially regulated by predation. However, unlike the literature on goshawk impacts on prey populations, the literature on predator impacts on goshawk populations is sparse and largely restricted to anecdotal reports. They are occasionally killed by large raptors, such as eagles (Squires and Ruggerio 1995) and great horned owls (Rohner and Doyle 1992), as well as mammals, such as pine martens (*Martes americana*), fishers, and raccoons (Paragi and Wholecheese 1994, Doyle 1995). Several studies have indicated that predation on goshawk nestlings may increase during periods of low goshawk food availability because female goshawks may be required to spend more time away from the nest foraging instead of protecting young (Zachel 1985, Rohner and Doyle 1992, Ward and Kennedy 1996, Dewey and Kennedy 2001).

Due to its wide distribution within the goshawk's geographic range, its size, abundance, and capacity for preying on large raptors, the great horned owl is one of the most important predators of goshawks (Orians and Kuhlman 1956, Hagar 1957, Houston 1975, Luttich et al. 1971, McInvaille and Keith 1974). Goshawks aggressively defend their nests against predators during the day. However, they are less capable of doing so at night and most reports of predation by great horned owls are losses of nestlings, although adults are occasionally taken (Rohner and Doyle 1992). The effect of great horned owl predation on goshawk populations is unknown (USFWS 1998b), but predation rates as high as 49% has been reported and suggest the owl's potential to impact goshawk nestling survival is great (Luttich et al. 1971). Great horned owls begin nesting earlier than goshawks and occasionally lay eggs in goshawk nests, forcing goshawks to construct or use alternative nest areas (Reynolds et al. 1994, Woodbridge and Detrich 1994). Alternative nest sites are often in close proximity, which may increase the potential for reciprocal predation between the goshawk, the owl, and their progeny (Gilmer et al. 1983, Rohner and Doyle 1992). Erdman et al. (1998) also reported an incident of a great horned owl feeding a female goshawk to its young.

Erdman et al. (1998) suggested fisher predation is a major cause of nest failure and incubating female mortality in northeastern Wisconsin, with annual turnover rates of nesting females exceeding 40%. Metal baffles have been used on nest tree trunks in this area since 1988 to reduce predation by mammals (Erdman et al. 1988), but the effectiveness of this technique has not been tested.

Duncan and Kirk (1995) reported that great horned owls, raccoons and fishers are the most significant predators of goshawks in Canada. Boal et al. (2002) reported that out of 5 adult goshawks depredated during the breeding season (4 females, 1 male) during 1998–2000, 2 deaths were caused by mammalian predation, 2 were caused by great horned owls, and one was caused by a diurnal raptor.

Little is known about the extent of predation on goshawks during winter. Squires and Reynolds (1997) reviewed reports of predation on goshawks, including instances by eagles (Squires and Ruggiero 1995) and martens in winter (Paragi and Wholecheese 1994).

Predation is a natural mortality factor in raptor populations. It is unknown if predation of goshawks is increasing due forest management or if predation rates are significantly reducing survival. However, studies on passerines suggest that in forested communities at some level of fragmentation and/or reduction of canopy cover, predation rates increase (Manolis *et al*. 2000, Zanette and Jenkins 2000).

A study documenting causes of mortality in Region 2 has not been conducted so the influence of predation on regulating Region 2 goshawk populations is unknown.

*Competition*

The extent to which interspecific competition for habitat and prey by potential competitors, such as the red-tailed hawk and great horned owl, affects goshawk habitat use is not well understood. In addition, these potential competitors also function as potential predators (see previous section) making the effect of their presence difficult to interpret. Goshawks may be excluded from nest areas by other raptors, although it is not uncommon for goshawks and other raptors to nest close to one another (Reynolds and Wight 1978). Great horned owls, spotted owls and great gray owls (*Strix nebulosa*) often breed in nests previously built by goshawks (Forsman et al. 1984, Bryan and Forsman 1987, Buchanan et al. 1993). In Minnesota, great gray owls have been observed using nests previously used by goshawks, with the goshawk pair building a new nest or using an alternative nest nearby (n = 3; A. Roberson, personal observation). Although Cooper's hawks and goshawks have a similar preference for nest habitat (Reynolds et al. 1982, Moore and Henney 1983, Siders and Kennedy 1996), and nest in the same stands (P. L. Kennedy unpublished data), Cooper's hawks are smaller than goshawks and begin nesting later (Reynolds and Wight 1978); thus, are unlikely to be effective nest site competitors.

This size effect on potential inter-specific competition has also been demonstrated for the common buzzard (*Buteo buteo*) which is a smaller-bodied raptor nesting sympatrically with the European goshawk. Krüger (2002a) recently did a multivariate discriminate analysis of nest site characteristics of the common buzzard (hereafter referred to as buzzard) and European goshawk (392 nests of both species combined). His results showed substantial overlap between the two species and he concluded this is good evidence for competition for optimal nest sites. The utility of niche overlap data for evaluating competition is debatable but it suggests the buzzard might be constrained by the larger-bodied European goshawk in its nest site selection. Krüger (2002b) then experimentally examined the behavioral interactions between buzzard and European goshawk and their effects on buzzard breeding success and brood defense using dummies and playback calls. Buzzards had significantly lower breeding success when presented with a goshawk dummy compared to control broods but there was no effect of buzzard dummies on buzzard reproductive success. European goshawks were far more aggressive against an intraspecific dummy than buzzards. Krüger concluded buzzards perceive a goshawk more as a potential predator rather than a competitor.

In addition to nest site competitors, several species of hawks and owls, and numerous mammalian predators can potentially compete with goshawks for prey (USFWS 1998b). The red-tailed hawk and great horned owl prey on many of the same species as goshawks (Fitch et al. 1946, Luttich et al. 1970, Janes 1984, Bosakowski and Smith 1992), although neither has the same degree of dietary overlap with goshawks as does the Cooper's hawk, which also forages in the same habitat (Storer 1966, Reynolds and Meslow 1984, Bosakowski et al. 1992). Because both the red-tailed hawk and great horned owl are more abundant in open habitats, such as meadows, edge, forest openings, and woodlands (Spieser and Bosakowski 1989), "the extent to which they coexist and compete for food with goshawks probably varies by the openness of forest types and extent of natural and anthropogenic fragmentation of a forest" (USFWS 1998b).

A variety of mammalian carnivores, including foxes (*Vulpes spp*.), coyotes (*Canis latrans*), bobcats (*Lynx rufus*), Canada lynx (*Lynx canadensis*), weasels (*Mustela frenata*), and pine martens are sympatric with goshawks in most North American forests and feed on some of the same prey species as goshawks, such as rabbits and hares, tree and ground squirrels, grouse, and other birds (USFWS 1998b). Erlinge et al. (1982) demonstrated the combined consumption of large numbers of small vertebrates by numerous sympatric species of carnivores, owls, and hawks in Sweden resulted in food limitations to the suite of predators.

Fragmentation of forested habitats can make the affected areas more accessible and attractive to competing species such as red-tailed hawks and great horned owls, thereby potentially decreasing habitat available to goshawks (USFWS 1998b). However, whether or not this is a linear relationship or some threshold level of fragmentation exists is unknown.

A detailed study of the predator-prey community in Region 2 is not available and the degree to which interspecific competition influences goshawk populations in Region 2 is unknown.

### *Parasites and disease*

Although disease has been documented in wild goshawks (Redig et al. 1980, Ward and Kennedy 1996, Lierz et al. 2002a, b), it is not believed to be one of the primary threats to goshawk populations. The USFWS found no data to show disease has a significant effect on the likelihood of long-term goshawk persistence in the western U.S. (USFWS 1998b). However, disease ecology is poorly understood and mortality by disease is difficult to identify without detailed necropsy data. Traditional ecological analyses have largely ignored the importance of disease in mediating ecosystem function and biodiversity (Real 1996) and there are numerous emerging infectious diseases developing that pose a substantial threat to wild animal populations (Daszak et al. 2000). Thus, I cannot assume that disease is not an important or potentially important regulating factor of goshawk populations.

Mortality from diseases may be exacerbated by changes in other limiting factors such as food shortage (Newton 1979). Redig et al. (1980) reported aspergillosus (*Aspergillus fumigatus*) in 53% of 49 goshawks trapped in 1972 and 7% of 45 in 1973 during migration at Hawk Ridge in Minnesota. They suggested the trapped goshawks were birds emigrating from northern forests due to low prey abundance, and the epizootic was the result of increased stress on the hawks due to increased agonistic interactions, reduced prey availability, and migration (Redig et al. 1980).

Internal parasites are common and heavy infestations of ectoparasites like lice (*Degeeriella nisus vagrans*) may occur in weakened birds (Keymer 1972 *in* Squires and Reynolds 1997, Lierz et al. 2002b). Greiner *et al.* (1975 *in* USFWS 1998a) estimated 56% of North American birds had blood parasites, including Leucocytozoon, Haemoproteus, Trypanosoma, and microfilariae. Trichomoniasis can be transmitted to raptors that ingest infected prey, usually columbids, which are hosts to *Trichonomonas gallinae*, a parasitic protozoan (Boal et al. 1998). It is apparently common in falconry birds (Szymanski and Houszka 2002). T. Erdman (personal communication to Dick and Plumpton 1998) reported trichomoniasis among goshawks in areas where pigeons are abundant in Wisconsin. Ward and Kennedy (1996) reported the cause of death of a nestling in New Mexico as heart failure due to severe fibrinous pericarditis on the heart caused by *Chlamydia tsittaci* and *E. coli*. Lierz et al. (2002a) found antibodies against falcon herpevirus in European goshawks found injured or debilitated and Lierz et la. (2002b) identified a new fluke (*Hovorkonema variegatum*) in raptors in a rehabilitated goshawk. The potential impact of west Nile virus (a newly observed avian disease in North America) on goshawk populations is unknown.

Information on disease in Region 2 goshawks is nonexistent.

### *Symbiotic and mutualistic interactions*

Most species are involved in some symbiotic or mutualistic relationships but I am not aware of any such relationship documented for the goshawk.

### *Model of ecological relationships*

To illustrate the ecological linkages described above I constructed an envirogram for the goshawk in Region 2 (**Figure 16**). Envirograms hypothesize the ecological linkages among direct and indirect factors and abundance of a species at a particular time and place (Andrewartha and Birch 1984). The advantage of the envirogram is that it helps the researcher and manager organize prior knowledge that spans multiple ecological levels while maintaining a focus on ecological factors (and processes) that directly or indirectly affect the size of a focal population (James et al. 1997). These ecological flow charts are developed using a standardized conceptual framework following the logic and terminology of Andrewartha and Birch (1984). I have used a modification of their approach developed by James et al. (1997) for the red-cockaded woodpecker (*Picoides borealis*).

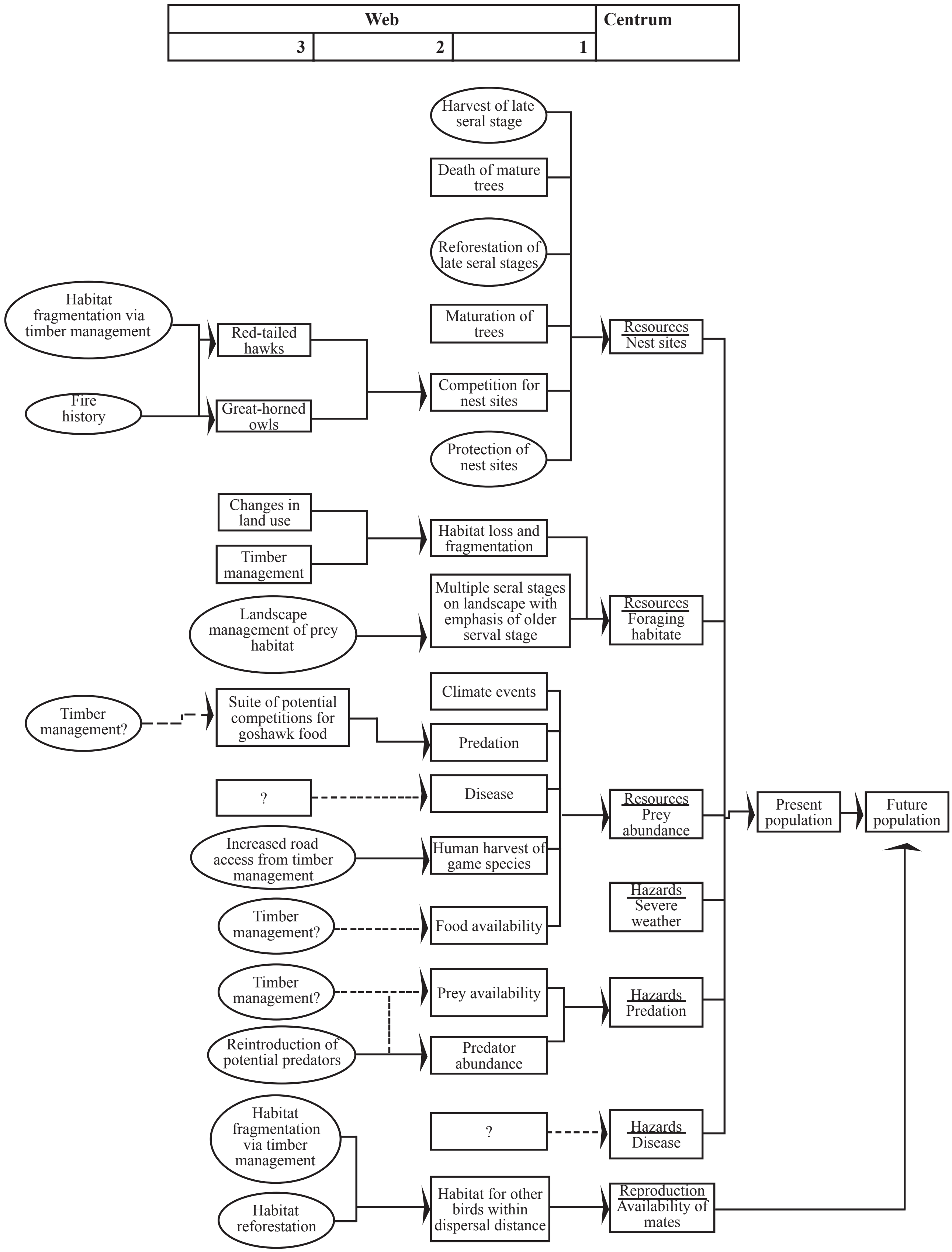


**Figure 16.** Envirogram for the northern goshawk in Region 2.

Envirograms depict each organism within the context of a *centrum* and *web*. The centrum is comprised of resources that directly affect the organism's abundance. Direct effects are categorized as resources, hazards or mates. Resources are environmental components that enhance the organism's chance of survival and reproduction and are either negatively or not influenced by the abundance of the organism (e.g., the goshawk's prey). Hazards reduce survival and reproduction in the focal population, and in turn, benefit from increases in the organism's abundance. Mates convey a positive-positive relationship. Indirect factors comprise the web and include anything that can affect a species by modifying its centrum, including the effects of individuals of the focal species on their own populations (e.g., density-dependent effects). Flow in an envirogram tends from distal indirect influences in the web toward the most proximate direct effects on the organism's population as shown in the centrum (Ward 2001). Similar to James et al. (1997) this envirogram contains submodels for limiting resources and hazards.

The number of factors and interactions depicted in an envirogram are limited only by the knowledge of the organism's ecology. I constructed the goshawk envirogram based on the information presented in this document. This envirogram is basically a hypothesis that could be used to develop models with goshawk abundance as the response variable and the factors influencing abundance as dependent variables. A wide variety of alternative envirograms could be developed with existing information and these models could be evaluated against empirical data using a wide variety of techniques. This envirogram is not expected to be comprehensive; it is just a schematic of possible interactions with an emphasis on the potential effects of forest management on the direct and indirect factors that could influence goshawk populations in Region 2.

In **Figure 16** current management practices that might influence goshawk numbers (described in next section) are indicated by ovals. As indicated, timber management practices in Region 2 can have a profound influence on all direct and indirect processes that influence goshawk numbers. Progressively more indirect effects appear in the columns of the web. For example, in the sub-model for nest site availability, if the number of large trees available for nest sites is limiting, the rate of maturation of younger trees must be balanced by the number of older trees lost to harvest and death for population stability. However, nest sites in good condition can be usurped by competitors and the abundance of competitors may be influenced by habitat fragmentation from timber harvest and fire. The other submodels reflect other processes that have been discussed in the narrative portion of this section.

The pathways could be made more specific if information was available on the types of management actions Region 2 is conducting that might negatively impact or enhance goshawk populations. This information was not available to me so it was not incorporated into **Figure 16**.

# Conservation

## *Threats*

There are a number of factors cited by researchers and managers as potentially detrimental to current and future goshawk viability. These include, but may not be limited to, habitat alteration, direct human disturbance, pesticides and other contaminants, and harvest for falconry. However, the primary concern throughout the range of the goshawk is habitat alteration due to timber and fire management practices.

### Habitat alteration

Biologists and land managers have raised concerns over destruction and modification of goshawk nesting, post-fledging, foraging, and wintering habitat (USFWS 1998b). The issues cited by researchers, agency personnel, and others as potential threats to habitat caused by various silvicultural treatments include forest fragmentation, creation of even-aged and monotypic stands, potential increase in area of younger age classes, and loss of tree species diversity.

As noted in the earlier sections on habitat, a number of studies describe structural characteristics of goshawk nest stands and goshawk landscapes but few data are available on the effects of logging within the nest stand on demographic performance, particularly in an experimental or quasi-experimental framework. Penteriani and Faivre (2001) recently helped fill this information gap with their quasi-experiment which is described in the next section.

Although only a few studies have been conducted on the responses of goshawks to forest management practices, there is clearly some level of habitat change that will render a landscape unsuitable for goshawks (USFWS 1998a). This level (or threshold) may vary spatially or temporally across the range of the goshawk. Thorough effects analysis of forest management on goshawk populations should consider the spatial relationships among different functional levels of habitat use by goshawks, including nesting habitat, foraging habitat, winter habitat, and important prey species and their habitat requirements (see the section on Post-fledging areas and multi-scale habitat studies for examples).

Habitat quality can be reflected in goshawk fitness, nesting success and productivity, degree of fidelity to breeding area and mate, size of home range and population densities of both goshawks and prey species (Reynolds et al. 1994). Forest management can impact the structure, function and quality of both nesting and foraging habitat by removing nests and nest trees, modifying or removing entire nest stands, and removing canopy and mature trees, snags, and downed wood (Reynolds 1989, Crocker-Bedford 1990, Bright-Smith and Mannan 1994, Woodbridge and Detrich 1994, Beier and Drennan 1997, Desimone 1997, USFWS 1998b). Reduction and fragmentation of habitat may favor early successional competitors and predators such as red-tailed hawks and great horned owls (Woodbridge and Detrich 1994).

Forest management practices, such as the use of controlled fire and thinning, may improve habitat for goshawks by opening up dense understory vegetation, creating snags, downed logs, woody debris, and other conditions that may benefit goshawks and their prey (Reynolds et al. 1992, Graham et al. 1999). To determine the effect of silvicultural prescriptions on potential nest habitat, expected post-harvest stand density and canopy closure should be compared to local definitions of mean structural attributes of nest area habitat (USFWS 1998b). Mean structural attributes of nest area habitat have not yet been determined for Region 2.

*Nesting and post-fledgling areas*

Negative effects of timber harvest on goshawk nest habitat can be described as the area of potentially suitable forest that meets local definitions from nest habitat studies, and that is modified to a condition no longer meeting the definition (USFWS 1998b). Desimone (1997) prescribed little or no habitat alteration within aggregate nest stands and Bright-Smith and Mannan (1994) stated that tree harvest methods that create large areas with reduced canopy cover of less than 35–40% may be particularly detrimental to potential goshawk nesting habitat. Reynolds (1989) stated that practices such as selective overstory removal or patch and clearcut harvesting, resulting in either a complete removal of trees or a reduction of the stem density and canopy cover throughout management units, lower the quality of goshawk nesting habitat. Reduction of canopy closure may result in increased solar radiation and heat stress, reduced buffering from adverse weather, and increased visibility to predators, all of which may singly, or in combination, affect goshawk nesting success (USFWS 1998a).

Using a quasi-experiment, Penteriani and Faivre (2001) tested some of these assumptions about within nest stand harvest. They examined the effects of shelterwood harvest within goshawk nesting stands on European goshawk occupancy and productivity. During this long-term study (1984-1995 in Italy and 1993-1999 in France) they compared trends in occupancy and productivity in logged and unlogged stands and also assessed the logging effects on the same nesting stand (n = 9 stands) before and after timber harvest. According to the authors, the forest system in both study areas is similar in terms of forest structure, scale and pattern of felling methods, method of regeneration and rotation length. In both areas, new growth is established mainly by clearance of the mature stand in successive felling steps. The harvest of mature and old-growth stands (which occurs primarily from mid-September to mid-April), which represents the typical nesting habitat of goshawks in both study areas, starts with a first light thinning, removing 10% of the stand trees. The regeneration process continues with 4 stages – 3 progressive steps of 20% felling and a final 30%. The time between the first thinning and the final removal is quite different for each mature stand but was generally 10 – 15 years where tree removal occurred once every 2 – 3 years.

Penteriani and Faivre (2001) found no difference in productivity of goshawk pairs reproducing in unlogged vs. logged stands. When considering the same nesting stand, before and after timber harvest, they noted no short-term differences in productivity. However, they observed that 87.5% of goshawk pairs nesting in logged stands moved away only when the original stand structure was altered by > 30% and then they moved only to the nearest neighboring mature stand. Although sample sizes were small, the results of this study suggest goshawks can tolerate some levels of timber harvesting within the nesting stand (if harvest is avoided from February through August), as long as cover reduction does not exceed approximately 30%. The applicability of this study to North America is unknown because there are no comparable studies to the Penteriani and Faivre (2001) study in North America.

Marzluff et al. (2000) suggest timber harvest and thinning could be used to manage (not simply increase as previously assumed) predator populations in mature and old-growth forests. Their findings from an extensive artificial nest experiment in marbled murrelet habitat in Washington suggest avian nest predator populations, such as corvids, can be reduced at broad spatial scales by timber harvest. They found predation rates of these artificial nests were correlated with abundance of corvids and stands of mature forests with uniform structure had significantly lower rates of predation than stands of complex or very complex ("old-growth") structure. Therefore, providing landscapes that include mixtures of simple-structured, mature forest, and old-growth forest (preferred nest site locations of murrelets) might reduce predator abundance. The applicability of this model to managing goshawk predators is unknown but worth considering and evaluating in an adaptive management framework. Also corvids are principal prey of goshawks in some areas so management for reducing corvids might negatively impact goshawk populations (Walters and Holling 1990, Walters and Green 1997).

Daw and DeStefano (2001) reported PFAs in Oregon are dominated by dense-canopied forest and always contain wet openings. Their findings support management recommendations that "call for maintaining the PFA in forest conditions intermediate between the high foliage volume and canopy cover of nest stands and more open foraging habitats" (Daw and DeStefano 2001).

Relatively few studies have addressed patch size of forest stands goshawks may select for nesting (USFWS 1998b). Based on observations of feathers, whitewash, and prey remains, Reynolds (1983) defined the nest area as approximately 12 ha of intensified use surrounding the nest. Woodbridge and Detrich (1994) suggested that although small (12–24 ha) stands were used successfully for nesting, goshawks preferred larger (34–80 ha) stands for nesting because occupancy rates of forest stands used for nesting decreased with decreasing stand size. The larger (83 ha) core area reported by McGrath et al. (in press) further supports the theory that larger patches of mature forest surrounding goshawk nests may be important (USFWS 1998b).

Although assessment of habitat condition for goshawk nest areas is often made at broad scales, there is evidence that landscape features such as slope, aspect, riparian vegetation, meadows, drainages, water, and other features affect location of goshawk nest areas (Allison 1996). Timber harvests associated with these physiographic features may have a disproportionate effect on habitat suitability if selection of nest areas by goshawks is at least partially dependant on them (USFWS 1998b) and nesting habitat is limiting.

One of the limitations of studies investigating the effects of timber harvest on goshawk nesting habitat is that few studies have investigated goshawk habitat in forests not managed for timber harvest. Studies of goshawk habitat relations conducted on timberland may reflect the history of timber harvest in those areas. Studies of goshawk habitat in protected areas, e.g., national parks, would provide baseline data that could be used to compare with habitat data from forest lands to determine the degree to which timber management influences goshawk habitat preferences. The Finn et al.

(2002) study described in the section on Post-fledging areas and multi-scale habitat studies included nest sites within Olympic National Park as well as on managed forest lands. They documented that loss of mature forest was detrimental to goshawk site occupancy and productivity in this area.

*Foraging areas*

Habitats used for foraging by goshawks in North America have been documented in a small number of telemetry studies (Austin 1993, Hargis et al. 1994, Bright-Smith and Mannan 1994, Beier and Drennan 1997, Boal et al. 2002). These studies suggest goshawks select foraging areas with specific structural attributes, including old or mature forest stands with open understories, relatively high canopy closure, large trees and high stem densities. It is possible, however, that actual foraging habitat selection occurs at spatial and temporal scales difficult to investigate using radio telemetry (USFWS 1998b). Small openings, tree fall gaps, edges, riparian zones, and rock outcrops are examples of small-scale landscape elements that may be important to foraging goshawks (Squires and Reynolds 1997).

Goshawk foraging success also depends upon habitat requirements of important prey species (Reynolds et al. 1992). Much of the current literature suggests goshawks are food-limited, particularly in low quality habitats, resulting in reduced fitness and reproduction, greater interspecific competition for food, and greater susceptibility to predators (USFWS 1998b, Reynolds et al. 2000). Food availability may also affect distribution and abundance of raptors, their breeding area or home range sizes, the proportion of pairs breeding, nesting success, and productivity (Schoener 1968, Southern 1970, Galushin 1974, Baker and Brooks 1981). Goshawks have been documented to forage away from forest cover in naturally open habitats if prey is available (Younk 1996, Woodbridge and Detrich 1994). It cannot be assumed, however, that adequate prey will necessarily be available in openings created by timber harvests, which often result in dense re-growth where goshawks would be unlikely to detect or capture prey (USFWS 1998b). Also, populations of many prey species are linked to structural attributes such as snags, large logs, large trees, soil organic horizon depth for fungi, and hardwoods for mast, and these may not be maintained under silvicultural prescriptions, unless specifically designed to maintain them (Reynolds et al. 1992, USFWS 1998b).

Goshawk foraging habitat can be maintained or restored through means such as protection of specific areas, control of tree spacing and canopy layering, and management strategies that sustain the structure, function, and ecological processes of forests that are important to goshawks (Reynolds et al. 1992, USFWS 1998b). Widén (1997) claims goshawk declines in Fennoscandia from the 1950s to the 1980s are a result of changes in forest management practices that have altered goshawk foraging areas in this region. In the 1950s forest management practices changed from selective cutting to clear-cutting, replanting and thinning. As a result of this intensive management, the boreal forest landscape of Fennoscandia is a highly fragmented patchwork of clearcuts and forest stands in different successional stages and the proportion of old-growth forest has declined dramatically (less than 5% of Swedish forests are old-growth). Widén develops a cogent argument that suggests this landscape change has caused goshawk declines by reducing the availability of foraging habitat not nesting habitat. Goshawks can successfully nest in small patches of mature or old-growth forest (as small as 0.4 ha), but their foraging ranges cover 2,000-6,000 ha, and in boreal forest in Europe they prefer large patches of mature forest for hunting. He suggests changes in the boreal landscape have resulted in a deterioration of goshawk hunting ranges, making it more difficult for them to secure adequate food for breeding. This factor is probably more important than a shortage of nest sites. He also notes declining prey densities (e.g., forest grouse and medium-sized mammals) may be associated with forestry which would affect goshawk numbers.

Although we know goshawk demography is strongly influenced by prey availability, the degree to which forest management positively or negatively influences prey availability is not well-documented. This is because most investigations of the effects of forest management on goshawk prey (medium-sized mammals and birds) typically correlate avian or mammalian abundance (and usually not both) with timber management using 1 to 3 replicates studied over 1-2 years. They are also generally conducted on too small of a spatial scale to be relevant to the goshawk (Marzluff et al. 2000). Marzluff et al. (2000) and Sallabanks et al. (2000) suggest some on-going avian studies are correcting these limitations by expanding their scale of investigation, using sound experimental design and relating forest management to avian demography. Such studies will increase our understanding of how forestry affects goshawk prey, particularly if they successfully identify the mechanisms that relate silviculture to prey population processes.

The degree to which habitat alteration is impacting goshawks in Region 2 is unknown.

#### *Fire suppression*

Goshawk nesting and foraging habitat has also likely been affected by fire suppression. Low intensity surface fires burned every 2 to 15 years in many ponderosa pine forests. Both stand replacing and surface fires occurred every 5 to 22 years in mixed conifer forests. Covington and Moore (1994; summarized in Braun et al. 1996) simulated the overall effects of fire suppression on the forest structure of southwestern ponderosa pine forests. The impacts are clear: forest density has increased, the herbaceous layer has almost disappeared and stream flow has reduced significantly. Fires now burn over larger areas, are more intense, and more devastating then in earlier times. Crown fires, particularly unheard of before 1940, are now common because of fire ladders provided by dense stands of saplings below the large trees and increasing canopy closure in these forests. The effects of fire suppression and mitigating fire management practices on goshawks are unknown.

#### *Human disturbance*

Human disturbance associated with forest management and other activities may affect goshawks and can cause nest failure, especially during incubation (Boal and Mannan 1994, Squires and Reynolds 1997). Camping near nests has caused nest failure (Speiser 1992). Disturbances associated with research are usually of short duration, and appear to have little impact on nesting birds (Austin 1993, Squires and Reynolds 1997, USFWS 1998b). The USFWS (1998b) reported that "disturbance generally does not appear to be a significant factor effecting the long-term survival of any North American goshawk population."

The degree to which goshawk populations in Region 2 are threatened by human disturbance is unknown.

#### Pesticides and other contaminants

In the early 1970s, pesticide levels were high in raptors in the U.S., such as peregrine falcons (*Falco peregrinus*), osprey (*Pandion haliaetus*) and sharp-shinned hawks (*Accipiter striatus*), but were low in goshawks (Snyder et al. 1973). Goshawks are less susceptible to pesticide accumulation than other accipiters, such as the Cooper's hawk, because the goshawk's prey species tend to accumulate less pesticide in their tissues (Rosenfield et al. 1991). The USFWS concluded pesticides and other contaminants appear to have not significantly affected goshawks in the United States (USFWS 1998b).

The degree to which goshawks are threatened by contaminants in Region 2 is unknown.

#### Overharvest

Although take of goshawks through shooting, trapping, poisoning or other means is generally illegal, falconry is one means by which live goshawks can be legally taken (USFWS 1998b). In an Environmental Assessment (EA) on falconry and raptor propagation regulations, the USFWS (1988) concluded falconry is a small-scale activity that has no significant biological impact on raptor populations. Mosher (1997) examined data reported by Brohn (1986) and falconers' annual reports and concurred with the conclusions reached by the USFWS.

In the Western Great Lakes region, various authors (Anonymous 1993c, Noll West 1998) have cited take of goshawks for falconry as a potential threat in that area. The impact of falconry on goshawk populations in Region 2 is unknown but it is probably not significant given the numbers harvested annually (See Falconry section for harvest numbers). No data are currently available to evaluate the number of goshawks that can be sustainably harvested from regional populations.

Overutilization of this species for commercial, scientific or educational purposes has not been reported for Region 2 and is unlikely to be occurring.

### Invasive species

The goshawk is not known to interact strongly with any exotic species that occur in Region 2 or elsewhere. Rock doves and starlings (both are exotics) have not been documented as frequent prey in the regional diet analyses. There is no information regarding the influence of exotic plant invasions on goshawk habitat and prey. The most important exotic plant invasions are occurring on unforested lands at lower elevations where changes in plant communities could influence winter goshawk habitat and prey populations (G. Hayward, USDA Region 2, personal communication).

## *Conservation of the Goshawk in Region 2*

### Is distribution and/or abundance declining in Region 2?

There is no evidence in North America that the goshawk is declining. In Europe the data are equivocal with the majority of information indicating stable or increasing populations. As I noted in 1997 (Kennedy 1997) the lack of evidence for North America can be interpreted in 3 ways: 1) the goshawk is not declining; 2) it is declining but we don't have sufficient information to detect the declines; or 3) the population is increasing but we don't have evidence. Options 2 or 3 are most applicable to Region 2 since there are little regional demographic data available so temporal trends in distribution and/or abundance cannot be evaluated.

Within the region, PIF state that the goshawk may be declining in the Central Rocky Mountain Physiographic Region, which occurs in the extreme northwest section. The basis for this conclusion is unknown.

### Do habitats vary in their capacity to support the goshawk in Region 2?

My review of the literature does suggest that habitats in Region 2 differ in their capacity to support goshawks. The limited data on goshawk breeding season nest sites and foraging habitat suggests that old or mature forest stands with open understories, relatively high canopy closure, large trees and high stem densities are selected. The limited regional data suggest that foraging areas are more likely to occur in mature forests on gentler slopes (6-60%), with open understories and greater densities of large conifers (23.0 – 37.5 cm dbh; range = 0-11 stems/0.04 ha). Evidence for use of openings for foraging is also available but limited. Older forests with more open or uniform understories would probably support goshawks more than older forests with complex or very complex forest structure.

Given that we can describe potential goshawk habitat in Region 2, how is this habitat distributed within the region? I approached this question by evaluating the distribution of mature and old-growth forest by forest type within the region (**Table 15** and **Table 16**). **Table 15** summarizes acreages of mature (habitat structural stage 4C) and old-growth (habitat structural stage 5C) forests for ponderosa pine and Douglas fir cover types for most National Forests in Region 2. No comparable data are available for mixed conifer forest. Acreages were also available for mature and old growth forest by forest type for each land allocation unit within most of the National Forests within Region 2 (16-24 land allocation units per National Forest; acreages were pooled over both habitat structural stages) (**Table 16**). The acreage data in **Table 15** and **Table 16** were provided by the regional office.

I calculated exploratory statistics with these data to determine if older forests are distributed evenly across land allocation units (**Table 16**). I examined the median and range of proportion of older forests within each landscape allocation unit. I also calculated an evenness index, O, for each cover type within each National Forest. There are several evenness indices for evaluating the distribution of landscape units or patches in a landscape. I chose O because of the 5 common evenness indices recently evaluated by Mouillot and Wilson (2002), O does not vary as much with variation in the number of units measured, e.g. number of landscape allocation units per forest, and it is more robust and unbiased as compared to other evenness indices. O is calculated as O = $\sum^{S} \min(p_i, 1/$ where S = the number of land allocation units, $p_i$ = proportion of HSS 4C+5C within a land allocation unit for each forest type. This index ranges from 0 to 1 where low numbers reflect a less even spatial distribution of older forests among land allocation units than do larger numbers. Similar to most indices, O is difficult to evaluate statistically so I did a qualitative evaluation of these measures. I arbitrarily determined that values of O within 10% of each other were probably not different.

Older forests (i.e., potential goshawk habitat) are not evenly distributed throughout the region (**Table 15** and **Table 16**). There is proportionally more acreage of older structural stages of Douglas fir (19.9% of the total acreage of this cover type) within the region then older structural stages of ponderosa pine (9.7% of the total acreage of this cover type). There are several plausible explanations for this pattern including: 1) a higher loss of older ponderosa pine forest in the region (cause of loss unknown); 2) the presence of edaphic, climatic and/or biological factors within the region that hinder successional development of older ponderosa pine forests more than older Douglas fir forests; or 3) this pattern reflects spurious results due to inaccuracies of the habitat structural stages to adequately portray vegetative structure and successional processes in regional forests. I do not have the data to evaluate these plausible scenarios.

How does this influence potential goshawk habitat in the region? If we assume HSS4C+5C is potential goshawk habitat, based on acreages of older forest (there is > 100,000 more acres of older Douglas fir forest), I would speculate there are more goshawks in the Douglas fir type then in the ponderosa pine type in Region 2. This might not occur if ponderosa pine is more suitable (i.e., 1 acre of ponderosa pine can support more goshawks than 1 acre of Douglas fir) as a cover type but there isn't sufficient information to compare the suitability of these two cover types.

Is there variation among forests in the acreage of older forest? Yes, older ponderosa pine and Douglas fir forest is not distributed evenly among National Forests (range 4.6-28.2%). The National Forests with the highest acreages are: White River (28.2%), Rio Grande (26.9%), and Bighorn (22.9%). In comparison, Shoshone (16.6%), Pike-San Isabel (12%) and Black Hills (11.7%) have intermediate levels of older forests and the combined Grand Mesa, Uncompagre and Gunnison National Forests has substantially lower acreages of older ponderosa pine and Douglas fir forests (4.6%). These results suggest that the availability of potential goshawk habitat varies by National Forest within Region 2.

Are older forests evenly distributed spatially within each national forest? The results (**Table 16**) suggest there isn't an even distribution of older forests within each forest. None of the National Forests in this sample had evenness indices (O) close to 1 and the ranges in proportion of older forests within landscape allocation units were large (**Table 16**). In all forests, older ponderosa pine forests were less evenly distributed then older Douglas fir forests. The highest evenness values were for the Douglas fir type in the Grand Mesa, Uncompagre and Gunnison NF (0.58), the Pike-San Isabel NF (0.51) and the White River NF (0.48). The lowest evenness values were for the ponderosa pine cover type in the Grand Mesa, Uncompagre and Gunnison NF and the Rio Grande NF (0.22). This suggests that goshawks are not likely to be uniformly distributed across the region. Where they occur could not be predicted given the limited data on spatial distribution of cover types.

Forest management activities that enhance the availability of these older forests, e.g., forest restoration, understory thinning, prescribed burns, could enhance goshawk populations. Alternatively, practices that reduce the availability of older forests, e.g., fire, would reduce goshawk population viability. Goshawk populations will not respond uniformly to these management activities across the region. Their response will be a function of both the availability of suitable habitat, i.e., acreage of older forests, and the conditions influencing regeneration of older forests. Forests with high regeneration rates as a function of

**Table 15.** Acreages (by forest) of older (HSS 4C + 5C)[2] ponderosa pine and Douglas fir forests[3] within Region 2.

| Forest[4] | Forest Type | Total Acreage | Acreage (%) HSS 4C + 5C[5] |
|---|---|---|---|
| Bighorn NF | Ponderosa Pine | 18,671 | 2,054 (11.0) |
| | Douglas Fir | 100,294 | 25,248 (25.2) |
| Shoshone NF | Ponderosa Pine | 199 | 0 (0.0) |
| | Douglas Fir | 413,563 | 68,738 (16.6) |
| Pike-San Isabel NF | Ponderosa Pine | 363,177 | 25,566(7.0) |
| | Douglas Fir | 447,416 | 71,674 (16.0) |
| Black Hills NF | Ponderosa Pine | 1,053,578 | 122,971 (11.7) |
| | Douglas Fir | 32 | 0 (0.0) |
| Grand Mesa + Uncompagre + | Ponderosa Pine | 109,482 | 889 (0.8) |
| Gunnison NF | Douglas Fir | 42,551 | 6,140 (14.4) |
| Rio Grande NF | Ponderosa Pine | 29,388 | 970 (3.3) |
| | Douglas Fir | 205,185 | 62,238 (30.3) |
| White River NF | Ponderosa Pine | 341 | 0 (0.0) |
| | Douglas Fir | 71,720 | 20,347 (28.4) |
| **TOTAL** | **Ponderosa Pine** | **1,574,836** | **152,450 (9.7)** |
| | **Douglas Fir** | **1,280,761** | **254,385 (19.9)** |

[2]HSS 4C is a habitat structural stage defined by the USFS as a mature stand of large to very large trees with most trees occurring in a diameter range of 12-18 inches with an interlocking crown (crown cover is > 70%). HSS 5C is a habitat structural stage defined as an old growth stand of large to very large trees with most trees occurring in a diameter range of 18-24 inches with an interlocking crown (crown cover > 70%).

[3]Data were provided by Region 2 and were only available for these 2 forest types.

[4]No data were available for the Arapahoe-Roosevelt, Medicine Bow-Routt, and San Juan Forests.

[5]Acreages for HSS 4C and 5C are pooled because acreages for each structural class for each forest type were not available.

**Table 16.** Distribution of mature (HSS 4C) and old-growth forest (HSS 5C) among land use allocations in each forest within Region 2.

| Forest (N)[6] | Forest Type | Median % of Old-Growth Forest in Landscape Units[7] (Range) | Evenness Index[8] |
|---|---|---|---|
| Bighorn NF (16) | Ponderosa Pine | 1.3 (0.0-27.1) | 0.44 |
| | Douglas Fir | 2.1 (0.0-38.7) | 0.46 |
| Shoshone NF (16) | Ponderosa Pine | NA | NA |
| | Douglas Fir | 1.4 (0.0-32.9) | 0.42 |
| Pike-San Isabel NF (17) | Ponderosa Pine | 0.7 (0.0-54.0) | 0.44 |
| | Douglas Fir | 1.9 (0.0-25.3) | 0.51 |
| Black Hills NF (21) | Ponderosa Pine | 1.1 (0.0-37.2) | 0.39 |
| | Douglas Fir | NA | NA |
| Grand Mesa + Uncompagre + Gunnison NF (16) | Ponderosa Pine | 0.1 (0.0-53.2) | 0.20 |
| | Douglas Fir | 4.4 (0.0-16.0) | 0.58 |
| Rio Grande NF (24) | Ponderosa Pine | 0.1 (0.0-39.3) | 0.22 |
| | Douglas Fir | 0.6 (0.0-27.2) | 0.40 |
| White River NF (21) | Ponderosa Pine | NA | NA |
| | Douglas Fir | 1.8 (0.0-20.9) | 0.48 |

[6]Each forest is spatially divided into land use allocations. N = the number of land use allocations in each forest. No data were available for the Arapahoe-Roosevelt, Medicine Bow-Routt, and San Juan Forests.

[7]This is the average proportion of acreage of HSS 4C + 5C structural classes within each land use allocation.

[8]This is an index of the distribution of old growth acreage among land use allocations within a forest. Eveness is calculated as: $O = \sum^{S} \min(p_i, 1/$ where S = the number of land allocation units, $p_i$ = proportion of HSS 4C+5C within a land allocation unit for each forest type. The index ranges from 0 to 1 where low numbers reflect a less even spatial distribution of older forests than do larger numbers.

their edaphic, climatic and disturbance patterns are likely to restore potential goshawk habitat at a faster rate than forests with lower regeneration rates.

Goshawks do hunt and nest in early seral stage forests and forest edges. However, these are typically smaller patches embedded in a larger matrix of older forest. These patches are probably openings created by natural disturbance processes in the region, e.g., fire, landslides, floods, wind throw. Thus, forest management practices designed to mimic regional natural disturbance regimes are less likely to lower goshawk population persistence than practices that do not mimic natural disturbance regimes. For example, in the San Juan Mountains in Region 2, prior to European settlement the median fire interval was only 10-20 years in lower elevation ponderosa pine, 20-30 years in dry mixed conifer, 50-100 years in aspen, and > 100 years in spruce-fir (Romme et al. 1998). Many individual stands escaped fire for longer intervals and some burned at shorter intervals, creating a complex mosaic of vegetation types on the landscape of the San Juan Mountains. Practices that recreate this landscape mosaic are likely to maintain goshawk populations in the San Juan Mountains. Practices that lead to greater homogeneity are likely to reduce goshawk populations.

### Does the goshawk's life history and ecology suggest that populations are vulnerable to habitat change?

Some of the goshawk's life history characteristics, i.e., low reproductive rate and delayed maturity, would suggest it is vulnerable to habitat change. Many would argue (e.g., Iverson et al. 1996) that it also occurs at low densities, which would increase its vulnerability. However, I am not convinced that its densities are low for a raptor. In some areas goshawk densities can be as high as 10-11 nests per 100 $km^2$. In addition, the species is a partial migrant, which is the most plastic migration strategy and thus, allows it to seasonally "escape" negative effects of habitat alteration if needed.

Demographic sensitivity analyses (Population status and viability section) indicate population growth rates are most sensitive to changes in adult survival rates, similar to other long-lived raptors (Noon and Biles 1990). Thus, habitat changes in Region 2 that reduce adult survival would probably decrease regional population persistence. In particular, forest management practices that reduce prey availability and increase predation risk could increase adult mortality, particularly during periods of stress (low prey years and cold weather). If prey availability is reduced from forest management practices conducted in breeding habitat, goshawks may be more likely to migrate. In this case, adult survival will then likely depend on the quality of winter low elevation habitat that is subject to alteration from processes such as urban sprawl and agroconversion. It is difficult to evaluate these potential effects because of the paucity of data on goshawks outside of the breeding season.

The influence of habitat alteration on successful dispersal of juvenile goshawks, or on adult movements is unknown.

The European literature suggests the goshawk exhibits resilience to forest fragmentation and can re-establish when cleared areas are reforested. The degree to which population persistence is related to habitat loss is graphically modeled in **Figure 17**. The simplest relationship would be a linear relationship where population persistence is proportionally related to the amount of habitat loss (**Figure 17**). This is the least likely scenario for the goshawk due to its apparent resilience to some degree of habitat loss. There is probably a threshold level below which the influence of habitat alterations on goshawk demography is undetected (**Figure 17**). Several researchers have suggested habitat thresholds may exist beyond which habitat alterations drastically influence species persistence (Noon and McKelvey 1996, Keitt et al. 1997, Hill and Caswell 1999, Howard et al. 2001). Alternatively, there may be an asymptotic effect of habitat removal on goshawk persistence where the initial effect of habitat removal is great and then it becomes negligible after a certain amount of habitat has been extracted (**Figure 17**).

The vulnerability of the goshawk to demographic and environmental stochasticity is unknown but I doubt it is a major threat to population persistence because population sizes and the species distribution are still relatively large.

### Are goshawk habitats declining or at risk in Region 2 under current management?

This is difficult to address in Region 2 because regional data are not available on the spatial and temporal trends of habitat change due to current management practices. However, a recent broad scale study by McGarigal et al. (2001) estimated cumulative effects of roads and logging on landscape structure in the San Juan Mountains of Colorado during the past 50 years. They used a variety of data sources to analyze changes in patch structure of mature forests over this time period.

I will summarize the results of this study below and its implications to goshawk populations in Region 2 with the caveat that goshawk data from the San Juan Mountains are not available so I will be speculating based on the preceding literature review.

McGarigal et al. (2001) selected an area of high-elevation forests on the Pagosa District of the San Juan National Forest in southwestern Colorado as their case study. The study area was 228,482 ha and it occupied the geographic center of the San Juan and South San Juan Ranges in the southern Rocky Mountains Province. It contains a large portion of the Weminuche and South San Juan Wilderness areas. If it is representative, their results should be representative of all areas in Region 2 within Physiographic Area 62 (**Figure 2**).

They found limited evidence for significant changes in landscape structure in their study area when all lands within the landscape were considered. The minor changes they observed reflected the vast buffering capacity of the large portion of lands managed for purposes other than timber. Roughly 84% of their study area presently cannot be logged because of administrative restrictions (e.g., wilderness, research natural areas), or because site conditions make it impractical (e.g., inaccessible, steep slopes) or inappropriate (nonforest cover). There are 37,045 ha of suitable forest lands in this study area. Significant changes in landscape structure and fragmentation of mature forest were evident in the suitable forest lands. Roughly half of the mature conifer forest was converted to young stands; mean patch size and core area declined by 40% and 25%, respectively. Overall roads had a greater impact on landscape structure than logging in their study area. The 3-fold increase in road density from 1950 to 1993 accounted for most of the changes in landscape configuration associated with mean patch size, edge density and core area.

These results suggest landscape structure has changed dramatically on intensively managed forest lands in Region 2 since the 1950s. The degree to which these landscape changes impact regional goshawk persistence is unknown. However, if the trend in the San Juan Mountains is representative of regional trends, suitable goshawk habitat is probably declining in Region 2 on lands managed intensively for timber. This is based on the assumption that goshawk nesting and foraging habitat is more likely to occur in older forests than in younger forests and habitat alterations that result in a net loss of older forests (i.e., loss is greater than replacement rate due to vegetative succession and/or restoration) is a negative impact to goshawks.

### Is there strong evidence that Region 2 goshawk populations are at risk and is the risk a consequence of land management?

There is some evidence that over a short time frame (the past 50 years) potential goshawk nesting and foraging habitat is declining in one area in Region 2 that is managed intensively for timber (McGarigal et al. 2001). However, the degree to which these data are representative of the entire region is unknown. There is also insufficient demographic data to determine if the habitat loss is resulting in population declines. If Penteriani and Favire's (2001) results are applicable to this region, goshawks are resilient to some level of habitat alteration in their nest stand if it isn't conducted during the nesting season. However, these thresholds for goshawks in Region 2 have not been identified and we have no information on goshawk responses to alterations in their foraging areas year round.

## *Goshawk Management in Region 2*

Region 2 currently lacks comprehensive management direction for goshawks. However, Reynolds et al. (1992) represents a potential framework for developing such management direction. Reynolds et al. (1992) cannot be applied as a "cookbook" to Region 2 because the habitat types and forest conditions differ. However, the approach could be modified for regional conditions by a team of biologists and silviculturists with regional expertise.

Managing goshawks regionally will require a management strategy similar to the one proposed by Grumbine (1997) for ecosystem management. The key to this type of management is interagency cooperation which has been initiated for goshawks in several other regions. A task force established and charged with developing and implementing a strategy for goshawk research and management in Region 2 could establish the direction for Region 2. This goshawk report represents the basis from which to identify research priorities in the region and to prioritize management issues.

## Tool and practices

### *Population monitoring*

There have been no attempts to estimate the population size of goshawks across Region 2. At a workshop concerning the goshawk in the Midwest, Andersen (1998) reported on the development of raptor monitoring strategies beyond the scale of single study areas and examined the current state of goshawk knowledge in terms of monitoring. Some issues important to the development of a regional, goshawk monitoring program listed by Andersen (1998) are relevant to developing a monitoring program for Region 2:

- ❖ Northern goshawks over much of this region likely forage on prey species whose populations may be cyclic or exhibit extreme variation in abundance (hare and grouse). This has important implications for population dynamics of goshawks and monitoring programs should anticipate variation in goshawk abundance.

- ❖ Little is known about the ecology of goshawks outside of the breeding season. Factors affecting survival and physical condition outside Region 2 may have impacts on population dynamics.

- ❖ Fall/winter invasions of goshawks from populations that breed farther north in the boreal forest of Canada and Alaska may influence population dynamics of Region 2 goshawks.

The monitoring of goshawks in Region 2 has been limited primarily to checks of known nest areas during the breeding season (Schultz et al. 2000). Without long-term population data, trends in population and their significance are difficult to evaluate. In their research and monitoring plan for goshawks in the Western Great Lakes Region, Kennedy and Andersen (1999) identified the survey method and the demographic method (see below) as the two general approaches to monitoring goshawk population trends. They also stress the importance of calculating and considering statistical power in designing a monitoring program so that the probability of detecting population trends is known (see also: Taylor and Gerrodette 1993, Journal of Wildlife Management 1995, Steidl et al. 1997, Gerard et al. 1998). Taylor and Gerrodette (1993) demonstrated that given a fixed amount of effort, the survey approach has a higher probability of detecting a decline in population size when densities are higher and the demographic approach has higher statistical power at lower densities. Kennedy and Andersen (1999) further discussed the pros and cons of various population monitoring techniques. They suggested that if habitat models are developed and validated to predict goshawk population performance, habitat-monitoring approaches could be used in conjunction with periodic population-based monitoring.

**Survey approach to population monitoring:** The survey approach to population monitoring attempts to estimate population size, or some index of population size, directly over several years and determines whether the estimates indicate a trend over time. Because it is not possible to census, or completely enumerate the entire population of most bird species, population monitoring is almost always based upon surveys of a sample of the breeding population (Kennedy and Andersen 1999). Surveys of breeding raptor populations are generally designed to monitor changes in distribution, occupancy of a sample of nests over time, and changes in breeding densities (Kennedy and Andersen 1999).

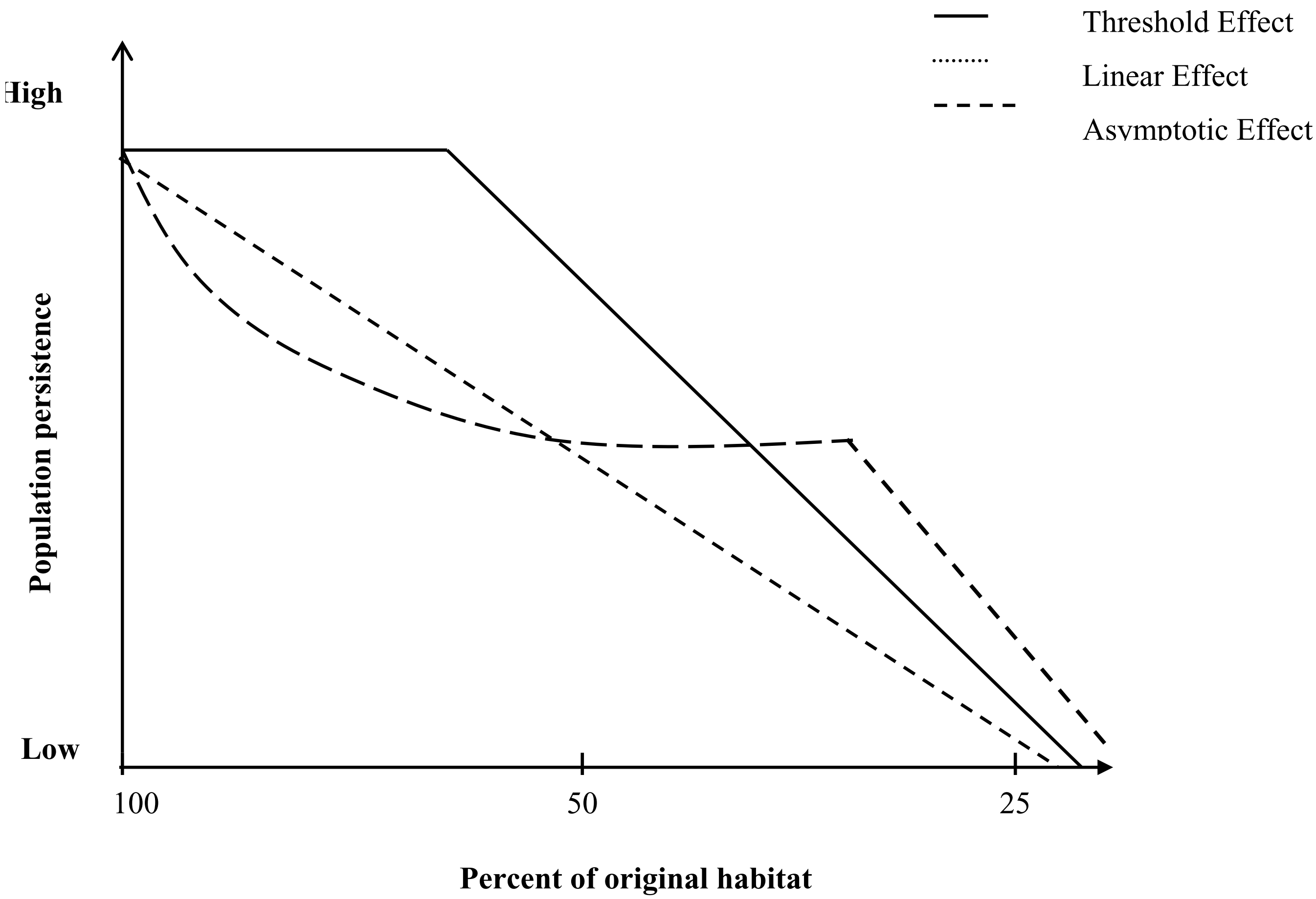


**Figure 17.** Hypothetical response curves demonstrating the influence of habitat loss around northern goshawk nest sites and goshawk population persistence.

Possible methods for locating nests to be used in monitoring programs include broadcast surveys, which can also be used to monitor area of occupancy or changes in distribution and densities. Foot surveys can also be effective in locating nests and may be combined with broadcast surveys. Aerial surveys may also have potential for finding goshawk nests in deciduous habitats, e.g., aspen (Kennedy and Andersen 1999). Each of these nest location methods has pros and cons, which are discussed in greater detail by Kennedy and Andersen (1999).

Ecological density, or the number of individuals per area of usable habitat, cannot be estimated in Region 2 until the range of habitats used by the goshawk in the region is identified (Kennedy and Andersen 1999). Abundance, a "crude" density estimate of number of individuals per unit of area, could be measured in a number of ways. Using simple tallies of nests to create an index to population size or to estimate breeding density in a study area produces biased estimates of population size (Gould and Fuller 1995). One way to estimate population size and breeding densities is to use capture-recapture data and Jolly-Seber Models for a well-defined study area. For this method to produce accurate population estimates with the desired statistical power, studies must be carefully planned and organized to ensure that study areas and number of goshawks pairs are large enough and that sampling effort and intensity are consistent among years (Kennedy and Andersen 1999). Gould and Fuller (1995) described the application of this approach to raptors.

Quadrat sampling, where the number of individuals within an area are counted and then divided by the size of the study area, may be the simplest way to estimate density (Kennedy and Andersen 1999). Rosenfield et al. (1996) used this approach in northern Wisconsin and it could be used in Region 2 with quadrats of similar size (or larger) randomly located within the ecoregions of the region (Kennedy and Andersen 1999). Kennedy and Andersen (1999) investigated the statistical power of this approach for detecting trends in breeding populations of goshawks. They found that power in estimating population trends was sensitive to breeding density of goshawks, plot size, number of plots monitored, and years of monitoring. If density estimates reported by Rosenfield et al. (1996) are representative of the region, the 3,800 ha plot-size used in their study would be a minimum size needed to attain adequate power to detect increasing or decreasing population trends. Kennedy and Andersen (1999) also suggested that 5 years of monitoring may not be adequate to achieve the desired statistical power and that any monitoring program for goshawks must be long-term. In addition, if the goshawk population is cyclic or irruptive, these complex dynamics reduce power and add complexity to data interpretation. Kennedy and Andersen (1999) stated that if goshawk populations are cyclic, a minimum of two cycles would have to be monitored before trends became apparent, which might substantially increase the time interval necessary to monitor populations.

Another approach that could be used to monitor goshawk populations would be the probability of detection–area occupied technique (McLeod and Andersen 1998, Bart and Robson 1995). Roberson (2001) found that using broadcast surveys of goshawks in north-central Minnesota resulted in a high probability of detection during the courtship and fledgling-dependency periods of the breeding season. Because she could estimate the probability of detection, she was able to estimate effective area surveyed (EAS) by a single broadcast station for her study area with her sample of goshawks. The EAS per broadcast station was 39.8 ha during the courtship phase and 34.4 ha during the fledgling-dependency phase. These results indicate that in northern Minnesota, broadcast stations may be spaced 712 m and 662 m, respectively, when conducting systematic surveys during these two breeding phases. She could not calculate the EAS for the nestling phase because the probability of detection was not a simple function of distance from nest. Calculation of the EAS could be applied to Region 2 once the probability of detection as a function of distance is known for broadcast surveys or whatever technique is used for locating goshawks. Her results may be useful in developing a technique to monitor breeding density if the relationship between estimates of area occupied and breeding density can be evaluated.

As discussed in the Population trends section, the utility of trends in migration counts for monitoring population trends is still being debated (Fuller 1996, Kennedy 1998, Smallwood 1998). One of the problems with migration counts is they are indices that have not been calibrated with any estimate of demography. Therefore, these indices are difficult to interpret. Trends in migration counts could reflect distributional changes and changes in residency patterns rather than changes in population size, particularly in species such as the goshawk, whose migrations are characterized by irruptive invasions (Kennedy and Andersen 1999).

**Demographic approach to population monitoring:** The demographic method involves monitoring trends in demographic parameters instead of monitoring abundance. For instance, survival and fecundity can be estimated, and used to calculate finite population growth rate ($\lambda$). $\lambda$ can be calculated based on following reproduction and survival of individual age classes, or can be estimated through simulation based on annual variation in cohort survivorship and reproduction. Advantages of the demographic method over the survey method are that it provides some explanation for observed population trends and it has higher statistical power when animal densities are low (Taylor and Gerrodette 1993).

Sallabanks et al. (2000) recommended that future research evaluating effects of timber harvest on bird populations measure parameters related to avian fitness and population viability. Braun et al. (1996) indicated that models designed to predict increases or declines in goshawk populations based on reproductive activity or survival alone have little validity because population trends are based on the cumulative effects of survival, reproduction, and dispersal. McClaren et al. (2002) also concluded that monitoring reproductive success in the absence of monitoring survival and/or recruitment has limited utility in monitoring programs unless reproductive success is being monitored in the framework of a quasi-experiment (see Penteriani and Faivre 2001 for an example). Although monitoring demographic parameters for goshawks is elegant, monitoring all vital rates would be extremely expensive and monitoring either survival or reproduction would provide an incomplete picture.

In analyzing temporal trends in reproductive success for two western goshawk populations, Kennedy (1997) found reproductive success was not correlated with population abundance and therefore monitoring reproductive success by itself is not a good index of population trends. Similarly, a meta-analysis of northern spotted owl datasets indicated reproductive success, compared to survival, had little relationship to abundance (Burnham et al. 1996, Raphael et al. 1996). Seven years of data on broad-winged hawk (*Buteo platypterus*) breeding density and reproduction also found no statistically significant or apparent relationships between reproductive success or productivity and breeding density in north central Minnesota (D. E. Andersen, unpublished data). Kennedy and Andersen (1999) also suggested monitoring goshawk population trends using demographic methods requires monitoring survival and reproduction or recruitment. They emphasized reproductive success should be determined by monitoring a representative and sufficiently large sample of nests that represents the larger population to which inferences are to be made. Precise survival estimates can be estimated by mark-resighting data from at least five years if sample sizes of marked birds and resighting rates are high (DeStefano et al. 1994b, Kennedy 1997). Survival can also be estimated from telemetry data using the Kaplan-Meier (1958) procedure or other survival estimates (Pollock et al. 1989). Monitoring territory occupancy also has promise as a monitoring approach because it may "integrate" survival and reproduction at least for the territory holders. However, calibration of occupancy trends with vital rate or abundance trends is necessary before such an approach could be implemented reliably and occupancy needs to be estimated in a rigorous fashion to avoid the potential for false negatives (Kennedy 1997, 1998, Dewey et al. in press).

### *Habitat-based monitoring*

Kennedy and Andersen (1999) suggested that if goshawk habitat can be well-defined and demographic data are available from several study areas for an analysis of population trends, a model (or models) that predicts relationships between preferred breeding season and winter habitat and population trends and/or performance could be developed. The rationale for switching to habitat-based monitoring has been clearly articulated by Roloff and Haufler (1997) and Lint et al. (1997) and includes cost-effectiveness in emphasizing the ecosystem rather than specific species and the ability to develop a more proactive management program (Kennedy and Andersen 1999).

Although extensive data on goshawk habitat preference is not available for Region 2, preliminary regional habitat models based on available regional information and the considerable information available from other regions and countries could be developed and parameterized to predict goshawk habitat (Kennedy and Andersen 1999). These models could be independently validated and modified once more extensive regional data are available. Kennedy (1997, 1998) suggested the most efficient way to identify consistent patterns in data collected in multiple studies is to conduct meta-analyses of the existing habitat literature. However, the meta-analysis is only an approach for model parameterization; it is not a replacement for model testing and validation. The habitat models would require testing with demographic data before such an approach could be implemented.

*If* models can be developed to predict goshawk population performance, then monitoring programs could switch emphasis from population-based to habitat-based monitoring. Reich et al. (in prep.) have recently developed a method to predict the location of goshawk nests on the Kaibab National Forest by modeling the spatial dependency between nest locations and forest stand structure. In the same area, Joy et al. (2000) have modeled small-scale variability in the composition of goshawk habitat on the Kaibab National Forest and plan to link these models with point-process models and a ranking of territories of northern goshawks with the purpose of identifying determinants of goshawk habitat quality.

Although goshawks may select habitat on the basis of structural characteristics and prey availability, they are also at the mercy of unpredictable factors such as drought, severe storms, or predation (Boal et al. 2002, T. Bloxton, J. M. Marzluff and D. E. Varland unpublished data). If habitat models do not adequately predict population performance and it is determined that habitat features do not drive goshawk population dynamics, a strictly habitat-based monitoring program may have limited ability to predict changes in goshawk demographic performance and population-based monitoring would need to be continued (Kennedy and Andersen 1999).

### *Habitat restoration approaches*

A review of habitat restoration or enhancement approaches that have been employed would be useful but it is beyond the scope of this document, particularly since the approaches used in Region 2 have not been documented.

## Information needs

As is evident from this document, considerable additional information is desirable regarding goshawk population dynamics, population monitoring, goshawk-habitat relations, and goshawk-prey interactions. Considerable additional information is needed before goshawks can adequately be incorporated into regional management plans. The following is an overview of information and research needs regarding goshawks in Region 2.

### *Population dynamics*

Existing data are inadequate to determine if Region 2 goshawk populations are declining, stationary, or increasing, or to identify habitat conditions, which result in sources of goshawk recruitment or in population sinks. A reliable regional model will require data from coordinated regional, systematic studies conducted over the long term (Sallabanks et al. 2000). In Region 2, no regional estimates exist for vital rates, dispersal movements are unknown, and populations have not been adequately defined. Data necessary to estimate population growth rates are not available for Region 2 or for any other North American goshawk population (Kennedy 1997).

Information on dispersal is important for investigating issues of population isolation and demography. Dispersal and mortality may be more important than reproduction in governing population dynamics; however, because they occur mainly outside of the nesting period, these factors are difficult to measure (Braun et al. 1996). Information on dispersal for regional populations would be helpful in reaching a better understanding of population dynamics.

The regular distribution of nesting pairs documented over many areas could result from the distribution of suitable habitat, territorial behavior, and/or some form of mutual avoidance. Understanding the mechanism by which goshawks distribute themselves over the landscape is important for management because density dependence (Maguire and Call 1992) and spacing behavior may limit the number of pairs an area can support below that dictated by availability of food or nest areas (Bernstein et al. 1991).

### *Population monitoring*

Kennedy and Andersen (1999) indicated that population monitoring based on a static sample of breeding areas is not sufficient to adequately monitor regional goshawk populations. Monitoring of breeding areas needs to include a strategy that results in a sample representative of the regional breeding population of goshawks. Kennedy and Andersen (1999) suggested this could be accomplished using stratified random sampling with an ecological basis for stratification. In addition, if preliminary results indicate goshawk densities are as high or higher than what has been reported for Wisconsin (Rosenfield *et al*. 1996), monitoring breeding densities using quadrat sampling and/or call broadcast surveys and the area occupied technique may be feasible. This approach would require a significant commitment of resources, but has the highest potential to track population changes and result in representative regional samples of goshawk breeding areas that could be used to evaluate demographics and factors affecting demographics. This approach is currently in the pilot study stage for Mexican spotted owls in the southwestern U.S. (Ganey et al. 1998). Well-designed sampling to locate breeding areas or to estimate breeding density should result in a representative sample of breeding areas, which could be used to characterize breeding habitat for goshawks.

*Habitat relationships and models*

There currently aren't sufficient regional data to develop a regional habitat model to predict suitable goshawk habitat or to predict habitat use in selected portions of the year. If preliminary models, based on the available regional information and relevant information from other parts of the goshawk's range, are developed and validated, any range-wide habitat patterns identified could be combined with silvicultural information for Region 2, and used to develop management guidelines for regional goshawk populations similar to the southwestern guidelines developed by Reynolds et al. (1992). As noted by Fuller (1996) "the concept of Reynolds et al. (1992) could be used as a model, for assessments and strategies in other areas and for other species. The concept is good because it incorporates the best available ecological and management information and considers a variety of species and forest conservation issues." Guidelines for Region 2 could be developed as a management hypothesis, tested in a portion of the region and modified if necessary depending upon the test outcomes (see Kennedy and Andersen 1999 for suggested approaches for habitat data collection in the Western Great Lakes Region).

Kennedy and Andersen (1999) identify the following questions as ones that regional habitat studies should focus on answering:

**1.** What is the structure and composition of high quality, breeding and wintering habitat at a variety of spatial scales?

**2.** What proportion of the total landscape is goshawk habitat?

**3.** What is the relationship between forest structure and prey availability and what features identify non-habitat?

**4.** What is the distribution of sizes of high quality habitat patches for nesting and foraging?

**5.** What is the distribution of distances (connectivity) between high quality habitat patches used for nesting and foraging?

The purpose of addressing questions 4 and 5 is to evaluate the degree of habitat fragmentation that occurs in goshawk habitat and to identify minimum (and maximum?) patch sizes and landscape conditions used by goshawks in Region 2.

*Goshawk diet and habitat requirements of their prey*

In addition, an understanding of how goshawks and their prey species are influenced by changes in forest structure and pattern resulting from forest management practices is critical to the development of sound goshawk conservation plans. Thus, it is important to determine goshawk prey use in Region 2 both in the breeding and non-breeding periods, and examine how prey species respond to changes in forest structure and landscape pattern, in terms of both abundance and availability (Kennedy and Andersen 1999).

*Landscape quasi-experiments*

As recommended by DeStefano (1998) and Kennedy (1998), Region 2 could conduct on-site experiments designed to measure goshawk responses to silvicultural treatments. An example of such an experiment is Penteriani and Faivre (2001). These quasi-experiments are being implemented continuously in the form of timber harvests near goshawk nests; most sale areas are identified years before the sale allowing for collection of adequate pretreatment data. Monitoring pre- and post-treatment movements of even a few pairs of birds would provide us with fascinating qualitative insights into goshawk responses to harvest and could be the basis for designing future experiments. I surmise that we would learn more (and spend fewer resources) about goshawk responses to forest management using this approach then we have learned from the hundreds of correlative studies conducted on goshawks.

*Management information*

As indicated earlier in the document, without a regional database on the past and future management activities conducted on each district, it is impossible to evaluate the regional threats and develop potential conservation scenarios. It is important that efforts be made to develop a database that could summarize the location, date and acreages of each timber management activity conducted in Region 2. The description of the timber management activities should also include type of activity and the immediate outcome in terms of changes in stand structure. A sample of these stands should be monitored to determine the structural and species composition changes in these stands over time. This information could also be added as a layer to this database. I would also suggest that the database include similar information on the forest management activities proposed in the forest plans. This would allow managers to predict the potential landscape changes that will occur regionally.

Finally, I have likely failed to address all of the issues relative to goshawk conservation in a regional context for Region 2. I view this concept document as a beginning, and not an end, to the development of a regional conservation strategy for the goshawk and other similar species — I encourage improvement.

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# LIST OF ERRATA

04/29/04 Changed Bergstorm 1985 to Bergstrom 1985 and Quires 2000 to Squires 2000 in **Table 9**.